The Department of Defense

DoD Departments:

Department of the Army

Department of the Navy

Defense Advanced Research Projects Agency

Special Operations Command

OSD

DDR&E

Office of Secretary of Defense Director Defense Research and Engineering

Program Solicitation 2001.2
Closing Date: 15 August 2001

FY 2001 Small Business Innovation Research (SBIR) Program

PROGRAM SOLICITATION

Number 01.2

Small Business Innovation Research Program

IMPORTANT

The DoD updates its SBIR mailing list annually. To remain on the mailing list or to be added to the list, send in the Mailing List form (Reference H) found at the back of this solicitation or complete the electronic form at www.pbcinc.com/sbir/pdf/ref_h.pdf. Failure to send the form annually will result in removal of your name from the mailing list.

If you have questions about the Defense Department's SBIR program, please call the SBIR/STTR Help Desk at (866) 216-4095, or see the DoD SBIR/STTR Web Site, at http://www.acq.osd.mil/sadbu/sbir.

U.S. Department of Defense
SBIR Program Office
Washington, DC 20301

May 1, 2001:	Solicitation issued for public release
July 2, 2001:	DoD begins accepting proposals
August 15, 2001:	Deadline for receipt of proposals at the DoD Components by 3:00 p.m. local time

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON DC 20301-3000

ACQUISITION AND
TECHNOLOGY

IMPORTANT NEW INFORMATION ABOUT THE DOD SBIR PROGRAM

1. **The DoD SBIR/STTR Help Desk** can address your questions about this solicitation, proposal preparation, contract negotiations, getting paid, government accounting requirements, intellectual property protection, commercialization reporting, the Fast Track, and other program-related areas. You may contact the Help Desk by:
   Phone: 866-216-4095 (8AM to 8PM EST)
   Fax: 866-888-1079
   Email: SBIRHELPDESK@pbcinc.com

2. **The DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir)** offers electronic access to many important resources for SBIR participants, such as the initial public release of each SBIR solicitation, sample SBIR proposals, model SBIR contracts, links to the Component SBIR programs within DoD, answers to commonly-asked questions about SBIR contracting, descriptive data on the SBIR program, and the latest program updates.

3. **Your SBIR Proposal Cover Sheet (formerly, "Appendix A and B") and Company Commercialization Report must now be submitted electronically through www.dodsbir.net/submission**, as described in Sections 3.4b and n.

4. **DoD has adopted commercialization of SBIR technology (in military and/or private sector markets) as a critical measure of performance** for both the DoD SBIR program and the companies that participate in the program. This new policy is reflected in Sections 3.4h and 3.6 of this solicitation (Commercialization Strategy); Section 3.4n (Company Commercialization Report on Prior SBIR Awards); Section 4.4 (Assessing Commercial Potential of Proposals); and Section 5.4 (Commercialization Report Updates).

5. **Under DoD's "Fast Track" policy (Section 4.5), SBIR projects that attract some matching cash from an outside investor for the Phase II effort receive expedited processing and interim funding between Phases I and II.** See http://www.acq.osd.mil/sadbu/sbir/fsttrack.html#results.

6. **Each DoD Component (Army, Navy, Air Force, etc.) has developed its own Phase II Enhancement policy.** Under this policy, the Component will provide a Phase II company with additional Phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD acquisition programs or the private sector. See each Component's section of the solicitation for details.

7. **You may contact the DoD authors of solicitation topics to ask questions about the topics** before you submit a proposal. Procedures for doing so are discussed in Section 1.5c of this solicitation. Please note that you may talk by telephone with a topic author to ask such questions only between May 1, when this solicitation was publicly released, and July 2, when DoD begins accepting proposals. At other times, you may submit written questions as described in Section 1.5c.

8. **A number of the Navy and Air Force topics is supported by a DoD acquisition program (e.g. New Attack Submarine)**, as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs is posted on the DoD SBIR/STTR Web Site, at http://www.acq.osd.mil/sadbu/sbir/acqprog/liaisons.htm.

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DoD PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

The Navy, Air Force, Defense Advanced Research Projects Agency (DARPA), Ballistic Missile Defense Organization (BMDO) Defense Threat Reduction Agency (DTRA), U.S. Special Operations Command (SOCOM), National Imagery and Mapping Agency (NIMA), and Chemical and Biological Defense (CBD) hereafter referred to as DoD Components, invite small business firms to submit proposals under this solicitation for the Small Business Innovation Research (SBIR) program. Firms with the capability to conduct research and development (R&D) in any of the defense-related topic areas described in Section 8.0, and to commercialize the results of that R&D, are encouraged to participate.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or research and development results.

The Federal SBIR Program is mandated by Public Laws PL 97-219, PL 99-443, PL 102-564 and PL 106-554. The basic design of the DoD SBIR Program is in accordance with the Small Business Administration (SBA) SBIR Policy Directive, January 1993. The DoD Program presented in this solicitation strives to encourage scientific and technical innovation in areas specifically identified by DoD Components. The guidelines presented in this solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector.

1.2 Three Phase Program

This program solicitation is issued pursuant to the Small Business Innovation Development Act of 1982, PL 97-219, PL 99-443, PL 102-564 and PL 106-554. Phase I is to determine, insofar as possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the SBIR Program. Phase I awards are typically $60,000 to $100,000 in size over a period not to exceed six months (nine months for the Air Force). Proposals should concentrate on that research or research and development which will significantly contribute to proving the scientific, technical, and commercial feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research or research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications.

Subsequent Phase II awards will be made to firms on the basis of results of their Phase I effort and the scientific, technical, and commercial merit of the Phase II proposal. Phase II awards are typically $500,000 to $750,000 in size over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research or research and development effort and is expected to produce a well-defined deliverable prototype. A more comprehensive proposal will be required for Phase II.

Under Phase III, the small business is expected to obtain funding from the private sector and/or non-SBIR Government sources to develop the prototype into a viable product or non-R&D service for sale in military and/or private sector markets.

Under a policy approved by the Under Secretary of Defense for Acquisition and Technology in October 1998, DoD now tracks the extent to which technologies developed under Phase II are successfully commercialized in Phase III (in military and/or private sector markets), as discussed in Section 5.4 of this solicitation. Furthermore, DoD has adopted such commercialization success as a critical measure of performance for both the DoD SBIR program and the firms that participate in the program.

This solicitation is for Phase I proposals only. Only proposals submitted in response to this solicitation will be considered for Phase I award. Proposers who were not awarded a contract in response to a prior SBIR solicitation are free to update or modify and re-submit the same or modified proposal if it is responsive to any of the topics listed in Section 8.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts will be considered (Section 4.3 and 5.2).

DoD is not obligated to make any awards under either Phase I, II, or III, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of any contract.

1.3 Proposer Eligibility and Limitations

Each proposer must qualify as a small business for research or research and development purposes as defined in Section 2.0 and certify to this on the Cover Sheet of the proposal. In addition, a minimum of <u>two-thirds</u> of the research and/or analytical work in Phase I must be carried out by the proposing firm. For Phase II, a minimum of <u>one-half</u> of the research and/or analytical work must be performed by the proposing firm. The percent of work is usually measured by both direct and indirect costs,

DOD SBIR/STTR WEB SITE:
http://www.acq.osd.mil/sadbu/sbir

although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their DoD contracting officer during contract negotiations. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization. Deviations from the requirements in this paragraph must be approved in writing by the contracting officer (during contract negotiations).

For both Phase I and Phase II, all research or research and development work must be performed by the small business concern in the United States. "United States" means the fifty states, the Territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 15 USC 631, and the definition included in Section 2.2.

1.4 Conflicts of Interest

Awards made to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees in violation of federal law. Such proposers should contact the cognizant Ethics Counselor from the employees' Government agency for further guidance.

1.5 Questions about SBIR and Solicitation Topics

a. General Questions/Information. The DoD SBIR/STTR Help Desk is prepared to address general questions about this solicitation, the proposal preparation process, contract negotiation, payment vouchers, Government accounting requirements, intellectual property protection, the Fast Track, financing strategies, and other program-related areas. The Help Desk may be contacted by:

Phone: 866-216-4095 (8AM to 8PM EST)
Fax: 866-888-1079
Email: SBIRHELPDESK@pbcinc.com

The DoD SBIR/STTR Web Site offers electronic access to SBIR solicitations, answers to commonly asked questions, sample SBIR proposals, model SBIR contracts, abstracts of ongoing SBIR projects, the latest updates on the SBIR program, hyperlinks to sources of business assistance and financing, and other useful information.

b. General Questions about a DoD Component. General questions pertaining to a particular DoD Component (Army, Navy, Air Force, etc) should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 8.0 of this solicitation.

c. Technical Questions about Solicitation Topics. On May 1, 2001, this solicitation was issued for public release on the DoD SBIR/STTR Web Site (**http://www.acq.osd.mil/sadbu/sbir**), along with the names of the topic authors and their phone numbers. The names of topic authors and their phone numbers will remain posted on the Web Site until July 2, 2001, giving proposers an opportunity to ask technical questions about specific solicitation topics by telephone.

Once DoD begins accepting proposals on July 2, 2001, telephone questions will no longer be accepted, but proposers may submit written questions through the SBIR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing. Proposers may submit written questions to SITIS via the Internet (see "Solicitations" on the DoD SBIR/STTR Web Site), e-mail, fax, mail, or telephone as follows:

Defense Technical Information Center
MATRIS Office, DTIC-AM
ATTN: SITIS Coordinator
NAS North Island, Box 357011
San Diego, CA 92135-7011
Phone: (619) 545-7529
Fax: (619) 545-0019
E-mail: sbir@dticam.dtic.mil
www: http://dticam.dtic.mil/sbir/

The SITIS service for this solicitation opens on or around May 16, 2001 and closes to new questions on August 1, 2001. SITIS will post all questions and answers on the Internet (see Solicitations on the DoD SBIR/STTR Web Site) from May 16, 2001 through August 15, 2001 (Answers will also be emailed or faxed directly to the inquirer if the inquirer provides an e-mail address or fax number.) Answers are generally posted within seven working days of question submission.

All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other information, relevant to the topic under which they are proposing.

1.6 Requests for Copies of DoD SBIR Solicitations

To remain on the DoD Mailing list for the SBIR and STTR solicitations, send in the Mailing List form (Reference H). You may also order additional copies of this solicitation from:

DoD SBIR Support Services
7000 North Broadway
Building 1, Suite #108
Denver, CO 80221
(866) 216-4095

The DoD SBIR and STTR solicitations can also be accessed via internet through the DoD SBIR/STTR Web Site at **http://www.acq.osd.mil/sadbu/sbir**.

1.7 SBIR Conferences and Outreach

The DoD holds two National SBIR Conferences a year and participates in many state-organized conferences for small business. For information on these events, see "Conferences" on our Web Site (**http://www.acq.osd.mil/sadbu/sbir**). We have a special outreach effort to socially and economically disadvantaged firms.

2.0 DEFINITIONS

The following definitions apply for the purposes of this solicitation:

2.1 Research or Research and Development

Basic Research - Scientific study and experimentation to provide fundamental knowledge required for the solution of problems.

Exploratory Development - A study, investigation or minor development effort directed toward specific problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions.

Advanced Development - Proof of design efforts directed toward projects that have moved into the development of hardware for test.

Engineering Development - Full-scale engineering development projects for DoD use but which have not yet received approval for production.

2.2 Small Business

A small business concern is one that, at the time of award of a Phase I or Phase II contract:

a. Is independently owned and operated and organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;

b. Is at least 51% owned, or in the case of a publicly owned business, at least 51% of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens;

c. Has, including its affiliates, a number of employees not exceeding 500, and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than investment companies licensed, or state development companies qualifying under the Small Business Investment Act of 1958, 15 USC 661, et seq., are affiliates of one another when either directly or indirectly (1) one concern controls or has the power to control the other; or (2) a third party or parties controls or has the power to control both. Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR Sec. 121.103. The term "number of employees" is defined in 13 CFR Sec. 121.106. Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association or cooperative.

2.3 Socially and Economically Disadvantaged Small Business

A small business that is at the time of award of a Phase I or Phase II contract:

a. At least 51% owned by an Indian tribe or a native Hawaiian organization, or one or more socially and economically disadvantaged individuals, and

b. Whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent-Asian Americans, or other groups designated by SBA to be socially and economically disadvantaged.

2.4 Women-Owned Small Business

A women-owned small business is one that is at least 51% owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management of the business.

2.5 Funding Agreement

Any contract, grant, or cooperative agreement entered into between any Federal Agency and any small business concern for the performance of experimental, developmental, or research work funded in whole or in part by the federal Government. *Only the contract method will be used by DoD components for all SBIR awards.*

2.6 Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government contract awardee calling for supplies or services required solely for the performance of the original contract. This includes consultants.

2.7 Commercialization

The process of developing a product or non-R&D service for sale (whether by the originating party or by others), in Government and/or private sector markets.

3.0 PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

A proposal to any DoD Component under the SBIR Program is to provide sufficient information to persuade the DoD Component that the proposed work represents an innovative approach to the investigation of an important scientific or engineering problem and is worthy of support under the stated criteria.

The quality of the scientific or technical content of the proposal will be the principal basis upon which proposals will be evaluated. The proposed research or research and development must be responsive to the chosen topic, although need not use the exact approach specified in the topic (see Section 4.1). Any small business contemplating a bid for work on any specific topic should determine that (a) the technical approach has a reasonable chance of meeting the topic objective, (b) this approach is innovative, not routine, and (c) the firm has the capability to implement the technical approach, i.e. has or can obtain people and equipment suitable to the task.

Those responding to this solicitation should note the proposal preparation tips listed below:

1) Read and follow all instructions contained in this solicitation, including the instructions in Section 8.0 of the DoD component to which you are applying.
2) Use the free technical information services from DTIC and other information assistance organizations (Section 7.1 - 7.4).
3) Mark proprietary information as instructed in Sec. 5.6.
4) Limit your proposal to 25 pages (excluding Company Commercialization Report).
5) Use a type size no smaller than 12 pitch or 11 point.
6) Register your firm on the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission) and, as instructed on the Web Site, prepare a Proposal Cover Sheet and Company Commercialization Report to be included in your proposal.

3.2 Proprietary Information

If information is provided which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting the national security, it will be treated in confidence to the extent permitted by law, provided it is clearly marked in accordance with Section 5.6.

3.3 Limitations on Length of Proposal

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal of no more than 25 pages, excluding Company Commercialization Report, (no type smaller than 11 point or 12 pitch on standard 8 " X 11" paper with one (1) inch margins, and a maximum of 6 lines per inch), *including Proposal Cover Sheet, Cost Proposal, and any enclosures or attachments*. Promotional and non-project related discussion is discouraged. <u>Cover all items listed below in Section 3.4 in the order given.</u> The space allocated to each will depend on the problem chosen and the principal investigator's approach. In the interest of equity, proposals in excess of the 25-page limitation (including attachments, appendices, or references, but excluding Company Commercialization Report <u>will not</u> be considered for review or award.

3.4 Phase I Proposal Format

a. Page Numbering. Number all pages of your proposal consecutively.

b. Proposal Cover Sheet. Register your firm on the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission). As instructed on the Web Site, prepare a Proposal Cover Sheet, including a brief technical abstract of the proposed R&D project and a discussion of anticipated benefits and potential commercial applications. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these sections. Print out a hard copy of the Proposal Cover Sheet from the Web Site and include it, with the appropriate signatures, as the first two pages of your proposal. Also include a photocopy of the signed Proposal Cover Sheet in the additional copies of the proposal that you submit per Section 6.0 of this solicitation. If your firm does not yet have access to the Internet, contact the DoD SBIR/STTR Help Desk (866/ 216-4095) for assistance.

c. Identification and Significance of the Problem or Opportunity. Define the specific technical problem or opportunity addressed and its importance. (Begin on Page 3 of your proposal.)

d. Phase I Technical Objectives. Enumerate the specific objectives of the Phase I work, including the questions it will try to answer to determine the feasibility of the proposed approach.

e. Phase I Work Plan. Provide an explicit, detailed description of the Phase I approach. The plan should indicate what is planned, how and where the work will be carried out, a schedule of major events, and the final product to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.

f. Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned

coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic.

Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

g. Relationship with Future Research or Research and Development.

(1) State the anticipated results of the proposed approach if the project is successful.
(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

h. Commercialization Strategy. Describe in approximately one page your company's strategy for commercializing this technology in DoD and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve and when (i.e., amount of additional investment, sales revenue, etc. – see items a through g in Section 5.4).

i. Key Personnel. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise resume of the principal investigator, including a list of relevant publications (if any), must be included.

j. Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in Reference A) shall be justified under this section. Also state whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

k. Consultants. Involvement of a university or other consultants in the project may be appropriate. If such involvement is intended, it should be described in detail and identified in Reference A. A minimum of <u>two-thirds</u> of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be carried out by the proposing firm, unless otherwise approved in writing by the contracting officer.

l. Prior, Current, or Pending Support of Similar Proposals or Awards. *Warning* -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

If a proposal submitted in response to this solicitation is substantially the same as another proposal that has been funded, is now being funded, or is pending with another Federal Agency or DoD Component or the same DoD Component, the proposer must so indicate on the Proposal Cover Sheet and provide the following information:

(1) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
(2) Date of proposal submission or date of award.
(3) Title of proposal.
(4) Name and title of principal investigator for each proposal submitted or award received.
(5) Title, number, and date of solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
(6) If award was received, state contract number.
(7) Specify the applicable topics for each SBIR proposal submitted or award received.

Note: If Section 3.4.1 does not apply, state in the proposal "No prior, current, or pending support for proposed work."

m. Cost Proposal. Complete the cost proposal in the format shown in Reference A of this solicitation for the Phase I effort only. Some items in Reference A may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. What matters is that enough information be provided to allow the DoD Component to understand how the proposer plans to use the requested funds if the contract is awarded.

(1) List all key personnel by <u>name</u> as well as by number on <u>hours</u> dedicated to the project as direct labor.
(2) Special tooling and test equipment and material cost may be included under Phases I and II. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.
(3) Cost for travel funds must be justified and related to the needs of the project.
(4) Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I proposal.

When a proposal is selected for award, the proposer should be prepared to submit further documentation to its DoD contracting officer to substantiate costs (e.g., a brief explanation of cost estimates for equipment, materials, and consultants or subcontractors).

n. Company Commercialization Report on Prior SBIR Awards. If your firm is submitting a Phase I or Phase II proposal, it is required to prepare a Company Commercialization Report through the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission) As instructed on the Web Site, list in the Report the quantitative commercialization results of your firm's prior Phase II projects, including the items listed in section 5.4a through g of this solicitation (sales revenue, additional investment, etc.). The Web Site will then compare these results to the historical averages for the DoD SBIR Program. Once your firm has completed the Report on the Web Site, print out a hard copy of the Report, sign and date it, and attach it to the back of your proposal.

As noted on the Web Site, your firm may also, at its option, include at the end of the Report additional, explanatory material (no more than five pages) relating to the firm's record of commercializing its prior SBIR or STTR projects, such as: commercialization successes (in government and/or private sector markets) that are not fully captured in the quantitative results (e.g. commercialization resulting from your firm's prior Phase I projects); any mitigating factors that could account for low commercialization; and recent changes in the firm's organization or personnel designed to increase the firm's commercialization success. The Company Commercialization Report and additional explanatory material (if any) will not be counted toward the 25-page limit for Phase I proposals.

A Report showing that a firm has received no prior Phase II awards will not affect the firm's ability to obtain an SBIR award. Firms that do not yet have access to the Internet should contact the DoD SBIR Help Desk (866/ 216-4095) for assistance.

3.5 Bindings

Do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.

3.6 Phase II Proposal Format

This solicitation is for Phase I only. A Phase II proposal can be submitted only by a Phase I awardee and only in response to a request from the agency; that is, Phase II is not initiated by a solicitation.

Each Phase II proposal must contain a Proposal Cover Sheet and a Company Commercialization Report (see Section 3.4b and n). In addition, each Phase II proposal must contain a two-page commercialization strategy, addressing the following questions:

(1) What is the first product that this technology will go into?
(2) Who will be your customers, and what is your estimate of the market size?
(3) How much money will you need to bring the technology to market, and how will you raise that money?
(4) Does your company contain marketing expertise and, if not, how do you intend to bring that expertise into the company?
(5) Who are your competitors, and what is your price and/or quality advantage over your competitors?

The commercialization strategy must also include a schedule showing the quantitative commercialization results from the Phase II project that your company expects to report in its Company Commercialization Report Updates one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc. – see items a through g in section 5.4).

Additional instructions regarding Phase II proposal preparation and submission will be provided or made available by the DoD Components to all Phase I winners at time of Phase I contract award.

3.7 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

Phase I proposals will be evaluated on a competitive basis and will be considered to be binding for six (6) months from the date of closing of this solicitation unless the offeror states otherwise. If selection has not been made prior to the proposal's expiration date, offerors will be requested as to whether or not they want to extend their proposal for an additional period of time. Proposals meeting stated solicitation requirements will be evaluated by scientists or engineers knowledgeable in the topic area. Proposals will be evaluated first on their relevance to the chosen topic. A proposal that meets the goals of a solicitation topic but does not use the exact approach specified in the topic will be considered relevant. (Prospective proposers should contact the topic author as described in Section 1.5 to determine whether submission of such a proposal would be useful.)

Proposals found to be relevant will then be evaluated using the criteria listed in Section 4.2. Final decisions will be made by the DoD Component based upon these criteria and consideration of other factors including possible duplication of other work, and program balance. A DoD Component may elect to fund several or none of the proposed approaches to the same topic. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by the DoD Components to make any awards on any topic, to make a specific number of awards or to be responsible for any monies expended by the proposer before award of a contract.

For proposals that have been selected for contract award, a Government Contracting Officer will draw up an appropriate contract to be signed by both parties before work begins. Any negotiations that may be necessary will

be conducted between the offeror and the Government Contracting Officer. It should be noted that only a duly appointed contracting officer has the authority to enter into a contract on behalf of the U.S. Government.

Phase II proposals will be subject to a technical review process similar to Phase I. Final decisions will be made by DoD Components based upon the scientific and technical evaluations and other factors, including a commitment for Phase III follow-on funding, the possible duplication with other research or research and development, program balance, budget limitations, and the potential of a successful Phase II effort leading to a product of continuing interest to DoD. DoD is not obligated to make any awards under Phase II or the Fast Track, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of a contract.

Upon written request and after final award decisions have been announced, a debriefing will be provided to unsuccessful offerors on their proposals.

4.2 Evaluation Criteria - Phase I

The DoD Components plan to select for award those proposals offering the best value to the Government and the nation considering the following factors.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal.

4.3 Evaluation Criteria - Phase II

The Phase II proposal will be reviewed for overall merit based upon the criteria below.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

The reasonableness of the proposed costs of the effort to be performed will be examined to determine those proposals that offer the best value to the Government. Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Phase II proposal evaluation may include on-site evaluations of the Phase I effort by Government personnel.

Fast Track Phase II proposals. Under the regular Phase II evaluation process, the above three criteria are each given roughly equal weight (with some variation across the DoD Components). For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in accordance with the above criteria, and may select these proposals for Phase II award provided:

(1) they meet or exceed criteria (a) and (b); and
(2) the project has substantially met its Phase I technical goals

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). Consistent with DoD policy, this process may result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

4.4 Assessing Commercial Potential of Proposals

A Phase I or Phase II proposal's commercial potential will be assessed using the following criteria:

a. The proposer's commercialization strategy (see Sections 3.4h and 3.6) and, as discussed in that strategy: (1) any commitments of additional investment in the technology during Phase II from the private sector, DoD prime contractors, non-SBIR/STTR DoD programs, or other sources, and (2) any Phase III follow-on funding commitments; and

b. The proposer's record of commercializing its prior SBIR and STTR projects, as shown in its Company Commercialization Report (see Section 3.4n). If the "Commercialization Achievement Index" shown on the first page of the Report is at the 5th percentile or below, the proposer will receive no more than half of the evaluation points available under evaluation criterion c in Sections 4.2 and 4.3 ("potential for commercialization"), unless the SBIR program manager for the DoD Component receiving the proposal (Army, Navy, Air Force, etc.) recommends, in writing, that an exception be made for that proposer, and the contracting officer

approves the exception.

A Company Commercialization Report showing that the proposing firm has no prior Phase II awards will not affect the firm's ability to win an award. Such a firm's proposal will be evaluated for commercial potential based on its commercialization strategy in item a, above.

4.5 SBIR Fast Track

a. In General. The DoD SBIR program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort (as well as for the interim effort between Phases I and II). The purpose is to focus SBIR funding on those projects that are most likely to be developed into viable new products that DoD and others will buy and that will thereby make a major contribution to U.S. military and/or economic capabilities.

Outside investors, as defined in DoD's Fast Track Guidance (Reference F), may include such entities as another company, a venture capital firm, an individual investor, or a non-SBIR, non-STTR government program; they do not include the owners of the small business, their family members, and/or affiliates of the small business.

As discussed in detail below, projects that obtain matching funds from outside investors and thereby qualify for the SBIR Fast Track will (subject to the qualifications described herein):

(1) Receive interim funding of $30,000 to $50,000 between Phases I and II;
(2) Be evaluated for Phase II award under a separate, expedited process; and
(3) Be selected for Phase II award provided they meet or exceed a threshold of "technically sufficient" and have substantially met their Phase I technical goals (and assuming other programmatic factors are met), as described in Section 4.3.

Consistent with DoD policy, this process should prevent any significant gaps in funding between Phases I and II for Fast Track projects, and result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

All DoD Components administer the Fast Track according to the procedures in this section, except for BMDO. BMDO administers slightly different procedures that have been approved by the Under Secretary of Defense for Acquisition and Technology – see the BMDO proposal instructions in Section 8 of this solicitation.

b. How To Qualify for the SBIR Fast Track. To qualify for the SBIR Fast Track, a company must submit a Fast Track application within 150 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track applications is specified by the DoD Component funding the project (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 120 to 180 days). The company is encouraged to discuss the application with its Phase I technical monitor; however, it need not wait for an invitation from the technical monitor to submit either a Fast Track application or a Fast Track Phase II proposal.

A Fast Track application consists of the following items:

(1) A completed Fast Track application form, found at Reference B of this solicitation. On the application form, the company and its outside investor must:
  (a) State that the outside investor will match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as described on the form at Reference B. The matching rates needed to qualify for the Fast Track are as follows:
    - For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)
    - For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)
  (b) Certify that the outside funding proposed in the application qualifies as a "Fast Track investment," and the investor qualifies as an "outside investor," as defined in DoD Fast Track Guidance (Reference F).

(2) A letter from the outside investor to the company, containing:
  (a) A commitment to match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as discussed on the form at Reference B.
  (b) A brief statement (less than one page) describing that portion of the effort that the investor will fund. The investor's funds may pay for additional research and development on the company's SBIR project or, alternatively, they may pay for other activities not included in the Phase II contract's statement of work, provided these activities further the development and/or commercialization of the technology (e.g., marketing).
  (c) A brief statement (less than one page) describing (i) the investor's experience in evaluating companies' ability to successfully commercialize technology; and (ii) the investor's assessment of the market for this particular SBIR technology, and of the ability of the company to bring this technology to market.

(3) A concise statement of work for the interim SBIR effort (less than four pages) and detailed cost proposal

(less than one page). Note: if the company has already negotiated an interim effort (e.g., an "option") of $30,000 to $50,000 with DoD as part of its Phase I contract, it need only cite that section of its contract, and need not submit an additional statement of work and cost proposal.

The company should send its Fast Track application to its Phase I technical monitor, with copies to the appropriate Component program manager and to the DoD SBIR program manager, as indicated on the back of the application form.

Also, in order to qualify for the Fast Track, the company:

(1) Must submit its Phase II proposal within 180 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track Phase II proposals is specified by the DoD Component funding the contract (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 150 days to 210 days).

(2) Must submit its Phase I final report by the deadline specified in its Phase I contract, but not later than 210 days after the effective start date of the contract (for the Air Force, not later than 270 days).

(3) Must certify, within 45 days after being notified that it has been selected for Phase II award, that the entire amount of the matching funds from the outside investor has been transferred to the company. Certification consists of a letter, signed by both the company and its outside investor, stating that "$______ in cash has been transferred to our company from our outside investor in accord with the SBIR Fast Track procedures." The letter must be sent to the DoD contracting office along with a copy of the company's bank statement showing the funds have been deposited. <u>IMPORTANT: If the DoD contracting office does not receive, within the 45 days, this certification showing the transfer of funds, the company will be ineligible to compete for a Phase II award not only under the Fast Track but also under the regular Phase II competition, unless a specific written exception is granted by the Component's SBIR program manager</u>. Before signing the certification letter, the company and investor should read the cautionary note at Section 3.7. If the outside investor is a non-SBIR/non-STTR DoD program, it must provide a line of accounting within the 45 days that can be accessed immediately.

Failure to meet these conditions in their entirety and within the time frames indicated will generally disqualify a company from participation in the SBIR Fast Track. Deviations from these conditions must be approved in writing by the contracting office.

c. Benefits of Qualifying for the Fast Track. If a project qualifies for the Fast Track:

(1) It will receive interim SBIR funding of $30,000 to $50,000, commencing approximately at the end of Phase I. Consistent with DoD policy, the vast majority of projects that qualify for the Fast Track should receive interim SBIR funding. However, the DoD contracting office has the discretion and authority, in any particular instance, to deny interim funding when doing so is in the Government's interest (e.g., when the project no longer meets a military need or the statement of work does not meet the threshold of "technically sufficient" as described in Section 4.3).

(2) DoD will evaluate the Fast Track Phase II proposal under a separate, expedited process, and may select the proposal for Phase II award provided it meets or exceeds evaluation criteria (a) and (b), as described in Section 4.3 (assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Consistent with DoD policy, this process should result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, DoD is not obligated, in any particular instance, to award a Phase II contract to a Fast Track project, and DoD is not responsible for any funds expended by the proposer before award of a contract.

(3) It will receive notification, no later than ten weeks after the completion of its Phase I project, of whether it has been selected for a Phase II award.

(4) If selected, it will receive its Phase II award within an average of five months from the completion of its Phase I project.

d. Additional Reporting Requirement. In the company's final Phase II progress report, it must include a brief accounting (in the company's own format) of how the investor's funds were expended to support the project.

5.0 CONTRACTUAL CONSIDERATIONS

Note: Eligibility and Limitation Requirements (Section 1.3) Will Be Enforced

5.1 Awards (Phase I)

a. Number of Phase I Awards. The number of Phase I awards will be consistent with the agency's RDT&E budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. No Phase I contracts will be awarded until all qualified proposals (received in accordance with Section 6.2) on a specific topic have been evaluated. Normally proposers will be notified of selection/non-selection status for a Phase I award within six months of the proposal's closing date. *The DoD Components anticipate making 230 Phase I awards from this solicitation.* On average, 1 in 8 Phase I proposals receive funding.

b. Type of Funding Agreement. All winning proposals will be funded under negotiated contracts and may include a fee or profit. The firm fixed price or cost plus fixed fee type contract will be used for all Phase I projects (see Section 5.5). *Note: The firm fixed price contract is the preferred type for Phase I.*

c. Average Dollar Value of Awards. DoD Components will make Phase I awards to small businesses typically on a one-half person-year effort over a period generally not to exceed six months (subject to negotiation). P.L. 102-564 allows agencies to award Phase I contracts up to $100,000 without justification. The typical size of award varies across the DoD Components; <u>it is therefore important for a proposer to read the introductory page of the Component to which it is applying (in Section 8.0) for any specific instructions regarding award size</u>.

d. Timing of Phase I Awards. Across DoD, the median time between the date that the SBIR solicitation closes and the award of a Phase I contract is 4 months.

5.2 Awards (Phase II)

a.Number of Phase II Awards. The number of Phase II awards will depend upon the results of the Phase I efforts and the availability of funds. *The DoD Components anticipate that approximately 40 percent of its Phase I awards will result in Phase II projects. This is merely an advisory estimate and the government reserves the right and discretion not to award to any or to award less than this percentage of Phase II projects.*

b. Type of Funding Agreement.
Each Phase II proposal selected for award will be funded under a negotiated contract and may include a fee or profit.

c. Average Dollar Value of Awards. Phase II awards will be made to small businesses based on results of the Phase I efforts and the scientific, technical, and commercial merit of the Phase II proposal. Average Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). PL 102-564 states that the Phase II awards may be up to $750,000 each without justification. <u>See special instructions for each DoD Component in Section 8.</u>

d. Timing of Phase II Awards. Across DoD, the median time between DoD's receipt of a Phase II proposal and the award of a Phase II contract is 6.5 months.

5.3 Phase I Report

a.Content. A final report is required for each Phase I project. The report must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page", will be used as the first page of the report. (A blank SF298 is provided in Reference E of this solicitation.) In addition, monthly status and progress reports may be required by the DoD agency.

b. Preparation.

(1) If desirable, language used by the company in its Phase II proposal to report Phase I progress may also be used in the final report.

(2) For each unclassified report, the company submitting the report should fill in block 12a (Distribution/Availability Statement) of the SF298, "Report Documentation Page" with one of the following statements:

(a) Approved for public release; distribution unlimited.

(b) Distribution authorized to U.S. Government Agencies only; contains proprietary information.

Note: The sponsoring DoD activity, after reviewing the company's entry in block 12a, has final responsibility for assigning a distribution statement.

(3) Block 13 (Abstract) of the SF 298, "Report Documentation Page") must include as the first sentence, "<u>Report developed under SBIR contract for topic [insert solicitation topic number]</u>". The abstract must identify the purpose of the work and briefly describe the work carried out, the finding or results and the potential applications of the effort. Since the abstract will be published by the DoD, it must not contain any proprietary or classified data.

(4) Block 14 (Subject Terms) of the SF 298 must include the term "SBIR Report".

c. Submission. The company shall submit <u>FIVE COPIES</u> of the final report on each Phase I project to the DoD in accordance with the negotiated delivery schedule. Delivery will normally be within thirty days after completion of the Phase I technical effort. The company shall, at the same time, submit <u>ONE ADDITIONAL COPY</u> of each report directly to the DTIC (unless instructed otherwise by the sponsoring DoD activity in the Phase I contract):

ATTN: DTIC-OCA
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218.

If the report is classified, the sponsoring DoD activity will provide special submission instructions. *Note: The sponsoring DoD activity has final responsibility for ensuring that the company or the DoD activity provide DTIC with all applicable Phase I and Phase II technical reports, classified and unclassified, developed under SBIR contract, per DoD Directive 3200.12 (http://web7.whs.osd.mil/dodiss/directives/direct2.htm).*

5.4 Commercialization Updates in Phase II

If, after completion of Phase I, the contractor is awarded a Phase II contract, the contractor shall be required to periodically update the following commercialization results of the Phase II project through the Web Site at **<u>www.dodsbir.net/submission</u>**:

a. Sales revenue from new products and non-R&D services resulting from the Phase II technology;

b. Additional investment from sources other than the federal SBIR/STTR program in activities that further the development and/or commercialization of the Phase II technology;

c. The portion of additional investment representing clear and verifiable investment in the future commercialization of the technology (i.e., "hard investment");
d. Whether the Phase II technology has been used in a fielded DoD system or acquisition program and, if so, which system or program;
e. The number of patents resulting from the contractor's participation in the SBIR/STTR program;
f. Growth in number of firm employees; and
g. Whether the firm has completed an initial public offering of stock (IPO) resulting, in part, from the Phase II project.

These updates on the project will be required one year after the start of Phase II, at the completion of Phase II, and subsequently when the contractor submits a new SBIR or STTR proposal to DoD. Firms that do not submit a new proposal to DoD will be asked to provide updates on an annual basis after the completion of Phase II.

5.5 Payment Schedule

The specific payment schedule (including payment amounts) for each contract will be incorporated into the contract upon completion of negotiations between the DoD and the successful Phase I or Phase II offeror. Successful offerors may be paid periodically as work progresses in accordance with the negotiated price and payment schedule. Phase I contracts are primarily fixed price contracts, under which monthly payments may be made. The contract may include a separate provision for payment of a fee or profit. Final payment will follow completion of contract performance and acceptance of all work required under the contract. Other types of financial assistance may be available under the contract.

5.6 Markings of Proprietary or Classified Proposal Information

The proposal submitted in response to this solicitation may contain technical and other data which the proposer does not want disclosed to the public or used by the Government for any purpose other than proposal evaluation.

Information contained in unsuccessful proposals will remain the property of the proposer except for the Proposal Cover Sheet. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by a proposer in a proposal which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the proposer with the term "confidential proprietary information" and provided that the following legend which appears on the Proposal Cover Sheet (Section 3.4b) of the proposal is completed:

"For any purpose other than to evaluate the proposal, the data referenced below shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a contract is awarded to the proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained on the pages of the proposal listed on the line below."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration and without assuming any liability for inadvertent disclosure. The Government will limit dissemination of properly marked information to within official channels.

In addition, each page of the proposal containing proprietary data which the proposer wishes to restrict must be marked with the following legend:

"Use or disclosure of the proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the Cover Sheet of this proposal."

If all of the information on a particular page is proprietary, the proposer should so note by including the word "PROPRIETARY" in both the header and footer on that page.

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event properly marked data contained in a proposal in response to this solicitation is requested pursuant to the Freedom of Information Act, 5 USC 552, the proposer will be advised of such request and prior to such release of information will be requested to expeditiously submit to the DoD Component a detailed listing of all information in the proposal which the proposer believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the proposer will ensure that any information released by the DoD Component pursuant to the Act is properly determined.

Those proposers that have a classified facility clearance may submit <u>classified material</u> with their proposal. Any classified material shall be marked and handled in accordance with applicable regulations. Arbitrary and unwarranted use of this restriction is discouraged. Offerors must follow the Industrial Security Manual for Safeguarding Classified Information (DoD 5220.22M) procedures for marking and handling classified material.

5.7 Copyrights

To the extent permitted by statute, the awardee may copyright (consistent with appropriate national security considerations, if any) material developed with DoD support. DoD receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

5.8 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a <u>period of five years</u> to allow the awardee to pursue a patent.

5.9 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this solicitation generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the <u>period commencing with contract award and ending five years after completion of the project</u> under which the data were generated. Upon expiration of the five-year restrictive license, the Government has unlimited rights in the SBIR data. During the license period, the Government may not release or disclose SBIR data to any person other than its support services contractors except: (1) For evaluational purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See FAR clause 52.227-20, "Rights in Data - SBIR Program" and DFARS 252.227-7018, "Rights in Noncommercial Technical Data and Computer Software -- SBIR Program."

5.10 Cost Sharing

Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of any Phase I proposal.

5.11 Joint Ventures or Limited Partnerships

Joint ventures and limited partnerships are eligible provided the <u>entity created</u> qualifies as a small business as defined in Section 2.2 of this solicitation.

5.12 Research and Analytical Work

a. For Phase I a minimum of <u>two-thirds</u> of the research and/or analytical work must be performed by the proposing firm unless otherwise approved in writing by the contracting officer.

b. For Phase II a minimum of <u>one-half</u> of the research and/or analytical work must be performed by the proposing firm, unless otherwise approved in writing by the contracting officer.

The percentage of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their contracting officer during contract negotiations.

5.13 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of Government contract clauses in the Phase I contract. The outline that follows is illustrative of the types of provisions required by the Federal Acquisition Regulations that will be included in the Phase I contract. This is <u>not a complete list</u> of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

a. Standards of Work. Work performed under the contract must conform to high professional standards.

b. Inspection. Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

c. Examination of Records. The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.

d. Default. The Government may terminate the contract if the contractor fails to perform the work contracted.

e. Termination for Convenience. The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

f. Disputes. Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.

g. Contract Work Hours. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).

h. Equal Opportunity. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. Affirmative Action for Veterans. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.

j. Affirmative Action for Handicapped. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. Officials Not to Benefit. No member of or delegate to Congress shall benefit from the contract.

l. Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

m. Gratuities. The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.

n. Patent Infringement. The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

o. Military Security Requirements. The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.

p. American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.14 Contractor Registration [NEW]

Before DoD can award a contract to a successful proposer under this solicitation, the proposer must be registered in the DoD Central Contractor Registration database. To register, see http://www.ccr2000.com/ or call 1-888-227-2423.

5.15 Additional Information

a. General. This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR contract, the terms of the contract are controlling.

b. Small Business Data. Before award of an SBIR contract, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to confirm responsibility of the proposer.

c. Proposal Preparation Costs. The Government is not responsible for any monies expended by the proposer before award of any contract.

d. Government Obligations. This Program Solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under this program are contingent upon the availability of funds.

e. Unsolicited Proposals. The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals will not be accepted under the SBIR Program in either Phase I or Phase II.

f. Duplication of Work. If an award is made pursuant to a proposal submitted under this Program Solicitation, the contractor will be required to certify that he or she has not previously been, nor is currently being, paid for essentially equivalent work by an agency of the Federal Government.

g. Classified Proposals. If classified work is proposed or classified information is involved, the offeror to the solicitation must have, or obtain, security clearance in accordance with the Industrial Security Manual for Safeguarding Classified Information (DoD 5220.22M). The Manual is available on-line at **http://www.dss.mil** or in hard copy from:

Defense Investigative Service
1340 Braddock Place
Alexandria, VA 22314
Phone: (703) 325-5324

6.0 SUBMISSION OF PROPOSALS

An original plus (4) copies of each proposal or modification will be submitted, in a single package, as described below, unless otherwise stated by specific instructions in Section 8.0.

NOTE: EACH PROPOSAL MUST CONTAIN A COMPLETED PROPOSAL COVER SHEET AND COMPANY COMMERCIALIZATION REPORT (see Section 3.4b and n).

6.1 Address

Each proposal or modification thereof shall be submitted in sealed envelopes or packages addressed to that DoD Component address which is identified for the specific topic in that Component's subsection of Section 8.0 to this solicitation.

The name and address of the offeror, the solicitation number, the topic number for the proposal, and the time and date specified for proposal receipt must be clearly marked on the outside of the envelope or package. To protect your proposal against rough handling, damage in the mail, and the possibility of unauthorized disclosures, it is recommended that your proposal be double-wrapped and that both the inner and outer envelopes or wrappings be clearly marked.

Offerors using commercial carrier services shall ensure that the proposal is addressed and marked on the outermost envelope or wrapper as prescribed above.

Mailed or hand carried proposals must be delivered to the address indicated for each topic. Secured packaging is mandatory. The DoD Component cannot be responsible for the processing of proposals damaged in transit.

All copies of a proposal must be sent in the same package. Do not send separate <u>information</u> copies or several packages containing parts of the single proposal.

6.2 Deadline of Proposals

Deadline for receipt of proposals at the DoD Component is 3:00 p.m. local time, August 15, 2001. Any proposal received at the office designated in the solicitation after the exact time specified for receipt will not be considered unless it is received before an award is made, and:

(a) it was sent by registered or certified mail not later than August 8, 2001.

(b) it was sent by mail or hand-carried (including delivery by a commercial carrier) and it is determined by the Government that the late receipt was due primarily to Government mishandling after receipt at the Government installation; or

(c) it was sent by U.S. Postal Service Express Mail Next Day Service-Post Office to Addressee, not later than 5:00 p.m. at the place of mailing on August 13, 2001.

Note: <u>There are no other provisions for late receipt of proposals under this solicitation.</u>

The only acceptable evidence to establish the date of mailing of a late proposal sent either by registered or certified mail is the U. S. Postal Service postmark on the envelope or wrapper and on the original receipt from the U.S. Postal Service. Both postmarks must show a legible date or the proposal shall be processed as if mailed late. "Postmark" means a printed, stamped, or otherwise placed impression (exclusive of a postage meter machine impression) that is readily identifiable without further action as having been supplied and affixed by employees of the U. S. Postal Service on the date of mailing. Therefore, offerors or respondents should request the postal clerk to place a legible hand cancellation bull's-eye postmark on both the receipt and the envelope or wrapper. Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of the installation on the proposal wrapper, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel. The only acceptable evidence to establish the date of mailing of a late proposal sent by Express Mail Next Day Service-Post Office to Addressee is the date entered by the post office receiving clerk on the "Express Mail Next Day Service-Post Office to Addressee" label and the postmark on both the envelope or wrapper and on the original receipt from the U.S. Postal Service. Therefore, offerors should request the postal clerk to place a legible hand cancellation bull's eye postmark on both the receipt and the envelope or wrapper.

Proposals may be withdrawn by written notice or a telegram received at any time prior to award. Proposals may also be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal. *(Note: the term <u>telegram</u> includes mailgrams.)*

Any modification or withdrawal of a proposal is subject to the same conditions outlined above. Any modification may not make the proposal longer than 25 pages (excluding Company Commercialization Report). Notwithstanding the above, a late modification of an otherwise successful proposal which makes its terms more favorable to the Government will be considered at any time it is received and may be accepted.

6.3 Notification of Proposal Receipt

Proposers desiring notification of receipt of their proposal must complete and include a self-addressed stamped envelope and a copy of the notification form (Reference C) in the back of this brochure. If multiple proposals are submitted, a separate form and envelope is required for each. Notification of receipt of a proposal by the Government does not by itself constitute a determination that the proposal was received on time or not. The determination of timeliness is solely governed by the criteria set forth in Section 6.2.

6.4 Information on Proposal Status

Evaluation of proposals and award of contracts will be expedited, but no information on proposal status will be available until the final selection is made. However, contracting officers may contact any and all qualified proposers prior to contract award.

6.5 Debriefing of Unsuccessful Offerors

An unsuccessful offeror that submits a written request for a debriefing within 30 days of being notified that its proposal was not selected for award will be provided a debriefing. The written request should be sent to the DoD organization that provided such notification to the offeror. Be advised that an offeror that fails to submit a timely request is not entitled to a debriefing, although untimely debriefing requests may be accommodated at the Government's discretion.

6.6 Correspondence Relating to Proposals

All correspondence relating to proposals should cite the SBIR solicitation number and specific topic number and should be addressed to the DoD Component whose address is associated with the specific topic number.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION ASSISTANCE

7.1 DoD Technical Information Services Available

The Defense Technical Information Center (DTIC) provides background technical information services at no cost, which can assist SBIR/STTR participants in proposal preparation, product development, marketing and networking.

The DTIC SBIR/STTR web site provides the following free services at **http://www.dtic.mil/dtic/sbir**:

1. **Public STINET and Web Enabled DROLS (WED):** Access DTIC's online technical databases including 37,000 plus full-text downloadable documents.
2. **OLTIPS** has bibliographies for each DoD SBIR and STTR topic
3. **Technical Reports**: Up to ten hard copy technical reports are available at no cost from DTIC during an SBIR, or a combined SBIR/STTR, solicitation period. Additional reports can be charged to a credit card or deposit account.
4. **TRAIL:** provides biweekly listings of new DTIC accessions matching the recipient's interests
5. **SITIS:** Interactive question and answer forum for specific technical questions concerning DoD topics, changes, and topic reference information.

DTIC is a major component of the DoD Scientific and Technical Information Program, making available technical information resulting from DoD-funded research and development **(http://www.dtic.mil).** DTIC also provides access to specialized information services. MATRIS is the focal point for information on manpower, training systems, human performance, and human factors **(http://dticam.dtic.mil).** The Information Analysis Centers (IACs) are the DoD centers of expertise concerned with engineering, technical and scientific documents and databases worldwide **(http://www.dtic.mil/iac/).**

Call DTIC (or visit by prearrangement at the location most convenient to you).

ATTN: DTIC-SBIR
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
Ph: (800) 363-7247
Fax: (703) 767-8228
Email: sbir@dtic.mil
www: http://www.dtic.mil/dtic/sbir

ATTN: DTIC-BPB
DTIC Northeastern Regional Office
DTIC-BOS
5 Wright Street
Hanscom AFB
Bedford, MA 01731-3012
Ph: (781) 377-2413
Fax: (781) 377-5627
Email: boston@dtic.mil

DTIC Southwestern Regional Office
ATTN: DTIC-BRNA
AFRL/VSIL/DTIC
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117-5776
Ph: (505) 846-6797
Fax: (505) 846-6799
Email: albuq@dtic.mil

ATTN: DTIC-BPD
DTIC Midwestern Regional Office
Bldg. 196, Area B
2261 Monahan Way
Wright-Patterson AFB, OH 45433-7022
Ph: (937) 255-7905
Fax: (937) 656-7002
Email: dayton@dtic.mil

ATTN: DTIC-BPL
DTIC Western Regional Office
Bldg. 80
2420 Vela Way, Suite 1467
El Segundo, CA 90245-4659
Ph: (310) 363-8980
Fax: (310) 363-8972
Email: losangel@dtic.mil

7.2 Other Technical Information Assistance Sources

Other sources provide technology search and/or document services and can be contacted directly for service and cost information. These include:

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
Ph: (703) 605-6000 or (800) 553-6847
Fax: (703) 605-6900
Email:info@ntis.fedworld.gov
www: www.ntis.gov

University of Southern California
Office of Patents and Copyright Administration
3716 South Hope Street, Suite 313
Los Angeles, CA 90007-4344
Ph: (213) 743-2282
Fax: (213) 744-1832
www: www.usc.edu/academe/otl

Center for Technology Commercialization
1400 Computer Drive
Westborough, MA 01581-5043
Ph: (508) 870-0042
Fax: (508) 366-0101
www: www.ctc.org

Great Lakes Technology Transfer Center/Battelle
25000 Great Northern Corporate Center, Suite 260
Cleveland, OH 44070
Ph: (440) 734-0094
Fax: (440) 734-0686
www: www.battelle.org/glitec/

Midcontinent Technology Transfer Center
Texas Engineering Extension Service
The Texas A&M University System
301 Tarrow
College Station, TX 77843-8000
Ph: (979) 845-2907
Fax: (979) 845-3559
www: www.teexweb.tamu.edu/tedd

Mid-Atlantic Technology Applications Center
University of Pittsburgh
3400 Forbes Avenue
Pittsburgh, PA 15260
Ph: (412) 383-2500
Fax: (412) 383-2595
www: www.mtac.pitt.edu
Southern Technology Application Center
University of Florida
1900 SW 34th Street, Suite 206
Gainesville, FL 32608-1260
Ph: (352) 294-7822
Fax: (352) 294-7802
www: www.state.fl.us/stac/

Federal Information Exchange, Inc.
555 Quince Orchard Road, Suite 360
Gaithersburg, MD 20878
Ph: (301) 975-0103
Ph: (800) 875-2562
Fax: (301) 975-0109
www: www.rams-fie.com

7.3 DoD Counseling Assistance Available

Small business firms interested in participating in the SBIR Program may seek general administrative guidance from small and disadvantaged business utilization specialists located in various Defense Contract Management activities throughout the continental United States. These specialists are available to discuss general administrative requirements to facilitate the submission of proposals and ease the entry of the small high technology business into the Department of Defense marketplace. The small and disadvantaged business utilization specialists are expressly prohibited from taking any action which would give an offeror an unfair advantage over others, such as discussing or explaining the technical requirements of the solicitation, writing or discussing technical or cost proposals, estimating cost or any other actions which are the offerors responsibility as outlined in this solicitation. (See Reference D at the end of this solicitation for a complete listing, with telephone numbers, of Small and Disadvantaged Business Utilization Specialists assigned to these activities.)

7.4 State Assistance Available

Many states have established programs to provide services to those small firms and individuals wishing to participate in the Federal SBIR Program. These services vary from state to state, but may include:
- Information and technical assistance;
- Matching funds to SBIR recipients;
- Assistance in obtaining Phase III funding.

Contact your State Government Office of Economic Development for further information.

8.0 TECHNICAL TOPICS

Section 8 contains detailed topic descriptions outlining the technical areas in which DoD Components request proposals for innovative R&D from small businesses. Topics for each participating DoD Component are listed and numbered separately. At least 20 percent of the Navy, Air Force, and Chemical Biological Defense topics either are authored by a DoD acquisition program (e.g., New Attack Submarine, Abrams Tank) or are of significant interest to such a program, as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs is posted on the DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir/acqprog/liaisons.htm).

Each DoD Component Topic Section contains topic descriptions, addresses of organizations to which proposals are to be submitted, and special instructions for preparing and submitting proposals to organizations within the Component. Read and follow these instructions carefully to help avoid administrative rejection of your proposal.

Many of the topics in Section 8 contain references to technical literature or military standards, which may be accessed as follows:

- References with "AD" numbers are available from DTIC, by calling 800/DoD-SBIR or sending an e-mail message to sbir@dtic.mil, or using the Document Request form at http://www.dtic.mil/dtic/sbir/service_req.html. Newer reports may be available for download after searching http://stinet.dtic.mil.
- References with "MIL-STD" numbers are available from the Department of Defense Single Stock Part for Military Specifications, Standards, and Related Publications at http://www.dodssp.daps.mil (or using the DTIC STINET interface at http://stinet.dtic.mil/str/dodiss4_fields.html.
- Other references can be found in your local library or at locations mentioned in the reference. Check SITIS for additional availability information.

U.S. ARMY
SUBMISSION OF PROPOSALS

Topics

The Army works to maintain its technological edge by partnering with industry and academia. Agile, free thinking, small, high tech companies often generate the most innovative and significant solutions to meet our soldiers' needs. The Army seeks to harness these talents for the benefit of our soldiers through the SBIR Program.

The Army participates in one DoD solicitation each year with a two-tiered Phase I and Phase II proposal evaluation and selection process. Army scientists and technologists have developed 250 technical topics and the Phase III dual-use applications for each which address Army mission requirements. Only proposals submitted against the specific topics following this introduction will be accepted.

The Army is undertaking a transformation to better meet small-scale contingencies such as the recent conflicts in the Balkans, Somalia and Haiti without compromising major theater war (e.g., the 1991 Gulf War) capability. This transformation has had a major impact on the entire Army Science and Technology (S&T) enterprise -- to include the SBIR program. On June 23, 1999, GEN Eric Shinseki, Chief of Staff of the Army, stated: "Heavy forces must be more strategically deployable and more agile with a smaller logistical footprint, and light forces must be more lethal, survivable and tactically mobile."

In practical terms this means being able to move an "Objective Force", for example, a Brigade (about 3,700 people and all warfighting equipment) anywhere in the world in 96 hours; a Division in 120 hours; and 5 Divisions in 30 days. It means, for example, replacing the Main Battle Tank, at 70 tons and 650 cubic feet, transportable only on a large C-5a or C-17 aircraft, with an equally lethal and survivable vehicle of less than half that weight and volume and transportable on the smaller C-130 aircraft. To supply the new weapon systems and supporting technologies needed by the Objective Force, the Army has initiated the Future Combat Systems (FCS) program. During 2000, the SBIR program was aligned with FCS and Objective Force technology categories -- this will obviously be an ongoing process as Objective Force/FCS needs change and evolve. All of the following Army topics reflect Objective Force and FCS technology needs. Over 60% of the topics also reflect the interests of the Army acquisition (Program Manager/Program Executive Officer) community.

Please Note!

✓ The Army requires proposers to submit the Proposal Cover Page (formerly Appendix A and B) and Company Commercialization Report (formerly, Appendix E) electronically. The Army will also accept the full technical proposal and the Cost Proposal (Reference A of this solicitation) via the Internet on a voluntary basis. Visit the Army SBIR Website (address: http://www.aro.army.mil/arowash/rt/) to get started. This page links to the DoD-wide SBIR proposal submission system (available directly at http://www.dodsbir.net/submission), which will lead you through the preparation of these forms. Refer to section 3.4n at the front of this solicitation for detailed instructions on the Company Commercialization Report. You must print out the Proposal Cover Sheet, Cost Proposal, and Company Commercialization Report directly from the Website, sign them, and submit them with the hard copies (1 original and 4 copies) of your proposal. Please note that a proposal is not considered accepted until the Army receives the entire packet in hard copy. **Improper handling of these forms may result in the proposal being substantially delayed. Information provided on the Company Commercialization Report will have a direct impact on the evaluation of the proposal.**

✓ Be reminded that section 3.4.b of this solicitation states: "If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet on the DoD SBIR/STTR web site (www.acq.osd.mil/sadbu/sbir/)"; therefore, do not include proprietary or classified information in these documents. Note also that the DoD web site contains timely information on firm, award, and abstract data for all DoD SBIR Phase I and II awards going back several years.

✓ ***Phase II Plus*** is a three-year pilot program which was implemented as of the release of the 99.2 DoD SBIR solicitation. The objectives of ***Phase II Plus*** are to (1) extend Phase II R&D efforts beyond the current Phase II contract to meet the product, process, or service requirements of a third party investor, preferably an acquisition program, and (2) accelerate the Phase II project into the Phase III commercialization stage. "Third party investor" means Army (or other DoD) acquisition programs as well as the private sector. The general concept is to provide qualified Phase II businesses with additional Phase II SBIR funding if they can obtain matching non-SBIR funds from acquisition programs, the private sector, or both. Under ***Phase II Plus***, additional funds may be provided by modifying the Phase II contract, and where appropriate, use will be made of the flexibility afforded by the SBA 1993 Policy which allows total Phase I + Phase II SBIR funding to exceed $850,000. Additional SBIR matching funds, subject to availability, will be provided on a one-to-one matching basis with third-party

funds, but not to exceed $100,000. The additional SBIR funds must be used for advancing the R&D-related elements of the project; third-party investor funds can be used for R&D or other business-related efforts to accelerate the innovation to commercialization. More information is available on the Army SBIR web site: http://www.aro.army.mil/arowash/rt/.

Phase I Proposal Guidelines

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase I - II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I is $70,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal if desired, covers activities over a period of up to four months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed $70,000 for the Phase I effort and $50,000 for the Phase I Option effort**. Only Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a resulting Phase II contract is $730,000, unless ***Phase II Plus*** funds are provided.

Companies submitting a Phase I proposal under this Solicitation must complete the Cost Proposal (Reference A of this solicitation and available online), within a total cost of up to $70,000 (plus up to $50,000 for the Phase I Option, if desired). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Cost Proposal. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare a Company Commercialization Report, for each proposal submitted. The Company Commercialization Report does not count toward the 25-page Phase I proposal limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, will be according to the evaluation procedures and criteria discussed in this solicitation, and will be based on priorities established to meet the Army's mission requirements. The first Criterion on soundness, technical merit, and incremental progress toward topic or subtopic solution (refer to section 4.2 at the front of this solicitation), is given slightly more weight than the other two evaluation criteria which are equal. When technical evaluations are essentially equal in merit between two proposals, cost to the government may be considered in determining the successful offeror. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation and unsolicited proposals will not be considered. Awards will be subject to the availability of funding and successful completion of contract negotiations. The Army typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award, at the discretion of the Contracting Officer.

Phase II Proposal Guidelines

Phase II proposals are invited by the Army from Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued in writing by the Army organization responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited, but the application must be received NLT 120 days after the Phase I contract is signed or by the Phase II submission date indicated later, whichever date is earliest. The Fast Track technical proposal is due by the Phase II proposal submission date indicated later. Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track program (see section 4.5 at the front of this solicitation) or the ***Phase II Plus*** program. Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3 at the front of this solicitation. Proposers are required to submit a budget for the entire 24 month Phase II period. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year, thus, proposers are advised to be mindful of this possibility. These costs must be submitted using the Cost Proposal format (Reference A of this solicitation and also accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet, Proposed Cost. At the Contracting Officer's discretion, Phase II projects may be evaluated after the base year prior to extending funding for the option year.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options effective with the 98.2 Solicitation, all Army Phase II proposals will receive expedited reviews and be eligible

for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single two-tiered evaluation process and schedule. Phase II proposals will thus typically be submitted within 5 months from the scheduled DoD Phase I award date (the scheduled DoD award date for Phase I, subject to the Congressional Budget process, is 4 months from close of the DoD Solicitation). The Army typically funds a cost plus fixed fee Phase II award, but may award a firm fixed price contract.

Submission of Army SBIR Proposals

All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Submit your proposal(s) well before the deadline. The Army does not accept late proposals.

All Phase I proposals - one (1) original (clearly marked, with original signatures) and four (4) copies - must be submitted to the Army SBIR Program Management Office at the address below. Each copy must include the Proposal Cover Sheet and the Company Commercialization Report (formerly Appendices A, B, and E) generated and printed out by the on-line systems. All hand deliveries must be made to the Army Materiel Command (AMC) building mail room, located at the rear of the AMC building. Proposers should be aware that the AMC mail room hours are 0730-1530 hrs (East Coast time) and are subject to change without prior notice. A confirmation of receipt form (Reference A) should be included with both hand delivered and mailed proposals, if desired. Confirmation of receipt will only occur with this form, accompanied by a self-addressed stamped envelope.

Dr. Kenneth A. Bannister
U.S. Army Research Office-Washington
Room 8N31, Army Materiel Command Building
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
(703) 617-7425

Electronic Submission of Proposals Using the DoD SBIR Proposal Submission System

You must submit your Proposal Cover Sheet to the Army using the online forms at the ARO-W web site: http://www.aro.army.mil/arowash/rt/, or available directly at the DoD Submission sit at http://www.dodsbir.net/submission. This site allows your company to come in any time (prior to the closing of the solicitation) to edit or print out your Proposal Cover Sheet, Company Commercialization Report, and the Cost Proposal. **The Army WILL NOT accept any form other than those from the DoD SBIR proposal submission system as valid proposal submissions.** The full Technical Proposal and Cost Proposal may be submitted using the online system at the proposer's discretion. The submission site limits the overall file size to 5MB or less for each electronic proposal submission. You are responsible for performing a virus check on each proposal to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. The Army will not accept e-mail submissions. You should contact your Internet Service Provider if you have questions concerning the provider's file size transmission allowance.

Key Dates

Phase I		Phase II	
01.2 Solicitation Open	1 July - 15 August 2001	Phase II Invitation	12 April 2002+
Phase I Evaluations	August - November 2001	Phase II Proposal Receipt	13 May 2002+
Phase I Selections	November 2001	Phase II Evaluation	June – July 2002
Phase I Awards	December 2001*	Phase II Selections	July 2002
		Phase II Awards	November 2002*

*Subject to the Congressional Budget process.
+ Subject to change; Consult ARO-W web site listed above

Recommendations for Future Topics

Small Businesses are encouraged to suggest ideas that may be included in future Army SBIR solicitations. These suggestions should be directed to the SBIR points-of-contact at the respective Army research and development organizations.

Inquiries

Inquiries of a general nature should be addressed in writing to:

Dr. Kenneth A. Bannister
Army SBIR Program Manager
U.S. Army Research Office - Washington
Room 8N31
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
(703) 617-7425
FAX: (703) 617-8274

ARMY SBIR PROGRAM
POINTS OF CONTACT (POC) SUMMARY

Research, Development and Engineering CTR	POC	PHONE
U.S. Army Materiel Command		
Armaments RD&E Center	John Saarmann	(973) 724-7943
Army Research Laboratory	Dean Hudson	(301) 394-4808
Army Research Office	Dr. Ellen Segan	(919) 549-4245
Aviation RD&E Center	Peggy Jackson	(757) 878-5400
Communications Electronics Command	Suzanne Weeks	(732) 427-3275
Edgewood Chemical Biological Center	Ron Hinkle	(410) 436-2031
Missile RD&E Center	Otho Thomas	(256) 842-9227
Natick Soldier Center	Dr. Gerald Raisanen	(508) 233-4223
Simulation, Training and Instrumentation	Joe Pellegrino	(407) 384-3960
Tank Automotive RD&E Center	Alex Sandel	(810) 574-7545
U.S. Army Test and Evaluation Command		
Developmental Test Command	John Schnell	(410) 278-1478
U.S. Army Corps of Engineers (Engineering Research Development Center)		
Construction Engineering Research Lab	Carol Mihina	(217) 373-6746
Cold Regions Research and Engineering Lab	Theresa Salls	(603) 646-4651
Topographic Engineering Center	Charles McKenna	(703) 428-7133
Waterways Experiment Station	Phil Stewart	(601) 634-4113
Deputy Chief of Staff for Personnel (Army Research Institute)		
Army Research Institute	Dr. Jonathan Kaplan	(703) 617-8828
U.S. Army Space and Missile Defense Command		
Space and Missile Defense Command	Dr. Doug Deason	(256) 955-1843
Army Medical Command		
Medical Research and Materiel Command	Herman Willis	(301) 619-2471

DEPARTMENT OF THE ARMY
PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the Army SBIR requirements. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award**. Do not include this checklist with your proposal.

____ 1. The Proposal Cover Sheets (formerly Appendix A and B) were completed using the SBIR proposal submission system, which can be accessed via the Army's SBIR Web Site (address: http://www.aro.army.mil/arowash/rt/) or directly at http://www.dodsbir.net/submission. The Proposal Cover Sheet clearly shows the proposal number assigned by the system to your proposal. The full technical proposal and cost proposal may be submitted Online at the proposer's discretion.

____ 2. The proposal addresses a Phase I effort (up to **$70,000** with up to a six-month duration) AND (if applicable) an optional effort (up to **$50,000** for an up to four-month period to provide interim Phase II funding).

____ 3. The proposal is limited to only **ONE** Army solicitation topic.

____ 4. The Project Summary on the Proposal Cover Sheet contains no proprietary information and is limited to the space provided.

____ 5. The Technical Content of the proposal, including the Option, includes the items identified in Section 3.4 of the solicitation.

____ 6. The Company Commercialization Report (online and hardcopy) is submitted in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)

____ 7. The proposal, including the Phase I Option (if applicable), is 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.

____ 8. The proposal contains only pages of 8-1/2" X 11" size. No other attachments such as disks or video tapes are included.

____ 9. The proposal contains no type smaller than 11-point font size (except as legend on reduced drawings, but not tables).

____ 10. The Cost Proposal (Reference A) has been completed, signed, and submitted for both **the Phase I and Phase I Option** (if applicable) and their costs are shown separately. The Cost Proposal is included as the last page of the proposal and the total cost should match the amount on the cover pages.

____ 11. The proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.

____ 12. One (1) original with original signatures **(clearly marked)** and four (4) copies of the entire proposal (signed Cover Pages, signed Company Commercialization Report, signed Cost Proposal, and Technical Proposal are submitted.

____ 13. Include a self-addressed, stamped envelope and a copy of the Notification Form (Reference C) located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal**.

____ 14. The proposal must be sent registered or certified mail, postmarked by August 9, 2001, or delivered to the Army SBIR Office no later than **August 15, 2001, 3:00 p.m. local time** as required (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. The Army **will not** accept responsibility for proposals delivered late by commercial couriers

ARMY 2001.2 TOPIC DESCRIPTIONS

A01-001 TITLE: Smart Materials for Future Combat System Cased Telescoped Ammunition (CTA) Gun Seals

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Tank and Medium-caliber Armament Systems

OBJECTIVE: Utilize Smart Materials (also known as shape memory alloys) such as NITINOL in cartridge case seals, located in the aft and forward end of cartridge case, to expand when required to seal out gun gases and then contract when needed to allow for an easily extractable cartridge case. This technology will allow for case telescoped ammunition (CTA) to be used in a rapid loading and unloading gun swing chamber, that needs to be sealed in the rear (breech end) and the front end of the swing chamber.

DESCRIPTION: Small Business and the U.S. Government have been increasingly utilizing smart materials, such as NITINOL, for innovate applications. This is due to the smart materials ability to change from a shape to a different trained shape, at a set temperature, and do substantial work. NITINOL is the most widely used smart material due to its added benefit of a super elastic property which can prevent kinking. Examples of uses of this technology and application is growing rapidly and can be found in eye glass frames and cell phone antennas that twist but do not break, stents in surgery that provide support to reattached vessels, valves that slam shut when sensing scolding hot water and in projectile that can change shape when in flight due to aerodynamic heating or cooling. ARDEC is presently developing a 105mm CTA for Future Combat Systems (FCS). CTA means that the projectile has been telescoped back into the cartridge case, as compared with conventional ammunition, where the projectile is attached to the front of the cartridge case. When viewing CTA ammunition only the front and aft seals and cartridge case show. All the other ammunition parts are internal and do not show. This makes CTA easier to use in a rapid autoloader system such as swing chamber. For the present CTA being developed for the 105mm FCS, The cartridge case is made of composite material and is attached between steel forward and aft seals. This attachment is a snap together saw tooth configuration which will dislocate at high pressures and then relocate after the high pressure disburses. During gun firings the aft and front seal dislocate from the cartridge case at each end and press against the forward and aft gun chamber of the swing chamber creating a propellant gas pressure seal. The steel seals must dilate (expand) with the gun chamber to maintain the gas seal. They then must return to their original shape after the gun pressure is dissipated. This allows for the spent (fired) cartridge case and seals to be removed from the gun chamber after firing since they are not consumed but must be robust enough to be ejected as a whole. NITINOL has a higher yield strength than steel (per unit elongation), it's less dense (therefore lighter per unit volume) and can be trained to take on a particular shape, instantaneously (can repeat this change reliably thousands of times without fatigue) at a set temperature. In this manner, it can be used as part of the front and aft seal of the FCS CTA cartridge case. There are two features that NITINOL may have an advantage in the design of these seals. Firstly, due to fact that the present seals are made of steel and are heavy, utilizing NITINOL for part of the seal will make it lighter. Secondly, the steel seals do not seal completely, do not always come back to shape and are subject to fatigue. Therefore, complete gas sealing and extraction from the gun after firing is not always reliably achieved. Using a NITINOL ring or sleeve as part of the seal may resolve this technical problem. The NITINOL (or other smart material) can be trained to expand when sensing hot gases and then contract when the gases are gone. Therefore, an instantaneous and tight gas seal can be achieved by the seal when needed and subsequently released after the gasses have dissipated for easy extraction of the spent cartridge case. This technology once proven in high-pressure gun systems can then be used in private industry for applications in high-pressure values and seals needed in the molding and manufacturing business.

PHASE I: Select candidate smart materials for seal design. Design smart material ring or sleeve that is compatible with cartridge case and seal designs. Study best manufacturing method to produce the ring or sleeve and train it to the needed shapes. Manufacture several prototypes and test their ability to mate with the seals and change shapes as needed. Metrics are being developed by ARDEC and will be available by April 2001. Baseline drawings will also be available during this time period.

PHASE II: Develop and manufacture prototypes to be used in piggyback R&D ballistic firings with the FCS CTA ammunition. Several iterations are expected until the technology is proven out and can become part of the FCS CTA seals. Detailed ballistic firings and schedules will be available from ARDEC by April 2001.

PHASE III: Presently, the small business community is the dominant player in developing, manufacturing and finding a market for smart materials. The sleeves or rings developed for this effort can be used in private industry where instantaneous, strong, lightweight seals are needed in high-pressure applications such as thermoplastic molding operations.

REFERENCES:
1) L. McDonald Schetsky, Shape-Memory Alloys, Scientific American, November 1979, Vol. 241 No5, pp74-82.
2) Tom Waram, Actuator Design Using Shape Memory Alloys, Copyright 1993, Published by: T.C. Waram, Hamilton, Ontario, Canada, Phone (905) 525-8251, ISBN 0-9699428-0-X.

3) Current websites: http//www.sma-inc.com, topics - intro. to shape memory and superelasticity - Setting shapes in Nitinol - Nitinol actuator wire properties. http//www.nitinol.com, topics - nitinol technology - nitinol applications

KEYWORDS: Smart materials, High-pressure seals, and Shape memory alloys

A01-002 TITLE: Innovative Adaptive Structures for Smart Munitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems (GCSS)

OBJECTIVE: Develop novel adaptive structures for the construction of gun fired projectiles with morphing and reconfiguration capabilities for drag reduction, range enhancement, and generation of guidance and control surfaces and means.

DESCRIPTION: The focus for the adaptive structures may very well be fins for stability purposes and/or canards used primarily for guidance. Other design concepts may attempt to modify portions of the typical cylindrical body shape to maximize parameters such as body lift for increased range. Such adaptive structures must be capable of withstanding the harsh launch and environmental conditions, including high pressures, shock, high temperatures and acoustic noise. The goal is to achieve these capabilities with minimal volume and weight penalty, system complexity and power requirement. The developed structures must also be capable of being readily integrated into the design of the Army's Future Combat System (FCS) Multi-Role Armament munitions, specifically the Smart Cargo Projectile (see Reference section below).

PHASE I: Design basic adaptive structures (fins/canards/body) for application on smart munitions, specifically the FCS Smart Cargo Projectile. Evaluate the feasibility and performance of each design, considering their survivability, reliability, and volume, weight and power requirements. Demonstrate and verify the chosen designs through analytical modeling and analysis, computer simulation and where necessary, component level proof-of-concept laboratory testing. Recommend the most promising design for development in Phase II of the project.

PHASE II: Develop a prototype of the most promising adaptive structural component designed in Phase I. It must be fully modeled and analyzed, and its operation and performance tested by physical proof-of-concept models before incorporation into the overall prototype. The prototype should be full size and functional for wind tunnel, high g load and other environmental condition testing.

PHASE III: For military purposes, the adaptive structural component will be integrated into the FCS Smart Cargo Projectile. The adaptive structural components can also be employed to reduce drag and increase lift in civil and military aircraft. These adaptive structures can also be used in other aerodynamic applications, ground vehicle applications, and hydrodynamic applications such as turbo machinery.

Reference Specification: Future Combat System Multi-Role Armament Smart Cargo Projectile proposed characteristics:
Length 800mm
Weight 18kg, Lightweight materials
Diameter 105mm, Maximize payload volume
G load approximately 20,000 G's
Range 4-50 km, Stability and Maneuverability

REFERENCES:
1) Bushko, D."High Bandwidth Magnetostrictive Actuator For Helicopter Electric Flight Control;"
SATCON Technology Corp., Cambridge, MA. 15 Apr 1994.
2) Roth, M.E., Taylor, L. M., Hansen, I. G., "Status Of Electrical Actuator Applications";
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.;
American Inst. of Aeronautics and Astronautics. NASA-TM-107319. Sep. 1996.
3) Collamore, F. N. Lister, M. J. "A Reliable, Low-Cost Electro-mechanical Actuator For The ALS Engine Control Effectors";
26th AIAA, SAE, ASME and ASEE, Joint Propulsion Conference, AIAA PAPER 90-1945.

KEYWORDS: adaptive structures, smart structures, reconfigurable structures, structural components, range extension, lift, drag reduction, FCS Smart Cargo Projectile, guided munitions.

A01-003 TITLE: <u>Innovative Conformal Power Sources for Advanced Smart Munitions</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Ground Combat and Support Systems

OBJECTIVE: To develop innovative renewable, rechargeable power sources that conform to the available space with any geometrical shape and that are capable of surviving and performing during gun setback environments, sometimes in excess of 100,000G's.

DESCRIPTION: The Army's Future Combat System (FCS) Munitions, such as the Smart Cargo Projectile (length 800mm, mass of 18kg, diameter of 105mm), will require innovative power sources to supply power to sensors, actuators, communications devices and/or integrated health monitoring and diagnostics. The FCS munition will require high capacity per unit volume power sources with fast discharge rates that conform to the geometry of the host structure or are even part of the structure to minimize the related volume requirements. Discharge rates of around 0.5 amps for a period of 2 hours at nominal voltages of 5-15 volts are highly desirable. An extended shelf life of 15-30 years for the entire range of storage conditions is also required. Candidate technologies must reduce the effective weight of the power source and must be able to survive harsh environments such as extremely large setback forces unique to high performance weapon systems up to 100,000 G's. Conformable power sources also must be designed to exhibit superior temperature range performance as compared to current state-of-the-art and have improved structural integrity as well. The drawback of the present technologies is the relatively low storage capacity per unit volume which limits the onboard power available for flight time performance requirements. Currently rechargeable capacitor technology and lithium thin film micro-batteries experiencing setback forces in excess of 70,000 G's have been used in high performance munitions to power communication links.

PHASE I: Develop feasibility concepts for innovative conformal power supplies that have the potential to meet the performance requirements of power, size, temperature, conformability, shelf-life and are capable of support structure system integration. Identify the optimum energy storage materials that meet the operating requirements over the operating environments (temperature, shock loading, etc).

PHASE II: Develop a prototype conformal power source from the optimized feasibility study from Phase I. Develop component-level performance metrics that reflect the multiple roles that conformal power sources will play in FCS applications.

PHASE III DUAL USE APPLICATIONS: The development of advanced conformal power sources will have broad applications within the military and commercial sectors. For military applications, test the structural integrity of successful designs under extreme harsh environments such as large accelerations in excess of 100,000 G's. Also test temperature performance over the entire military range and perform system level tests, addressing issues such as performance, survivability, reliability, production, manufacturing and shelf life as required in the FCS system. For commercial applications, there exists a huge potential for portable consumer products requiring increased power with reduced size, weight, and cost - for example, portable PC's, cell phones, camcorders, palmcorders, etc.

REFERENCES:
1) HSTSS Battery Development for Missile & Ballistic Telemetry Applications Lawrence W. Burke, Edward Bukowski, US Army Research Laboratory Lolin Newnham, William Hoge, Neil Scholey, Zhlyaunye YE, Ultra Life, Inc.
2) Bailey, J.C., 1999, "Comparison of Rechargeable Battery Technologies for Portable Devices," Conference on Small Fuel Cells and the Latest Battery Technology, Bethesda, MD.
3) Gozdz, A., 1999, "Flat Li-ion Batteries," Conference on Small Fuel Cells and the Latest Battery Technology, Bethesda, MD.

KEYWORDS: consumable structures, smart structures, disposable structures, structural components, range extension, drag reduction, FCS Munitions; Smart Cargo Projectile, guided munitions.

A01-004 TITLE: Innovative Guidance and Control Algorithms for Small Caliber Projectiles

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: Joint Services Small Arms Program (JSSA)

OBJECTIVE: To develop guidance and control algorithms for the Light Fighter Lethality (LFL) Seeker High Explosive Projectile.

DESCRIPTION: In the Future Warrior 2025 concept, each warrior system will be tailored to the individual combatant. The goal is to have a system that will weigh no more than 15 percent of the body weight of the individual. The LFL Seeker Projectile is one of the Lethality Components of the Future Warrior. The Seeker Projectile concept is based on the Projectile knowing the target location at Launch. This could be either the latitude and longitude of the enemy soldier or it could be the range and azimuth of the enemy soldier. The projectile is provided this information and when launched flies autonomously under a slow roll to the target coordinates. During the initial stages of projectile flight, the projectile guidance and control system determines its orientation and position, knows how far it is off its initial trajectory, using this on board inertial reference platform measuring device, and activates its maneuver mechanism as required. As the projectile approaches the target, the seeker is first activated and images only when "flagged" by the guidance and control system. The seeker detect/recognizes the target, stationary or moving. With this information, the seeker electronics on board the projectile interfaces with the guidance and command unit which directs the projectile to maneuver and engage the target. Key parameters to be evaluated are: accuracy of vertical reference during flight, accuracy of roll angle, accuracy of "flagging" the seeker, the accuracy of longitudinal and lateral acceleration integration to obtain present position, and the timeliness of these parameters. In addition, separation of transient projectile response to side force control from trajectory deviation from target, and seamless integration of inertial and simulated IR imaging seeker information in formulating trajectory control commands.

It is envisioned that for an initial proof of principle demonstration, the projectile will be approximately 25mm in diameter, 5 inches in length and will have a weight of 0.5 lbs. The range of this rocket boosted projectile is 500 meters and will be launched at a muzzle velocity of approximately 190 feet per second and a time of flight to impact is around 4 seconds. As technology advances, the size and weight of the projectile will be reduced.

PHASE I: Investigate algorithms for the guidance and control unit of the Light Fighter Lethality Seeker Projectile. These algorithms will receive target location and time of flight information from the weapon fire control system at launch, receive projectile in-flight characteristics from the Inertial Measurement Unit, and provide course correction commands throughout the projectile's flight. The algorithms will keep track of lateral and angular projectile motion induced by side force control inputs. When the seeker is activated as the projectile approaches the target, the algorithms will insure proper orientation, and flag the seeker to image. The algorithms will accept seeker input, and integrate it with previously described trajectory parameters, to correct the course and engage the target. These algorithms will be written in FORTRAN 90. These algorithms will be used as software-in-the-loop together with a six degree of freedom trajectory simulation to check trajectory correction fidelity.

PHASE II: The algorithms developed in Phase I will be demonstrated by implementing them in a breadboard guidance and control unit. The breadboard guidance and control will be capable of receiving simulated Infrared (IR) imaging seeker inputs. The accuracy of the guidance and control algorithms will be measured while the breadboard is undergoing a slow roll at the projectile roll rate of the Light Fighter Lethality Seeker High Explosive Projectile. A Government owned multi-axis seeker test table may be used for this test, if requested by the proposer.

PHASE II: A commercial application of the results of the effort is a safety device for light aircraft. This guidance and control technology could be applied to light aircraft as a mid-air collision warning device. Light aircraft do not have this capability today. This technology would be lightweight, small in size, and would be applied to video processing of images for the aircraft applications. This technology could be responsible for saving lives by reducing possible mid-air collisions. This effort will also have applications to other weapon systems. A goal for future small caliber systems is to "reduce miss distance to maximize lethality". This can be accomplished with projectiles that can improve their probability of hit. With this capability, fewer projectiles will be required to incapacitate the target. These small caliber projectiles will need guidance and control systems. These small caliber projectiles have tight space and weight constraints, and very short times of flight as compared to larger caliber systems. Therefore, scaling down of large caliber systems is not a solution. The results of this effort can be applied to the Medium Cannon Caliber Guided Projectile Program, the Objective Crew Served Weapon and the Objective Individual Combat Weapon. This technology can also be applied to bomblets and sub-munitions for other services weapon systems.

REFERENCES:
1) Innovative Guidance & Control Algorithms for Small Caliber Projectiles, author: Lucian Sadowski,
2) http://www.dtic.mil/ndia/smallarms/dindl-sado.pdf

KEYWORDS: Guidance and Control, Inertial Measurement Unit, Global Positioning Systems, IR imaging system technology

A01-005 TITLE: Innovative High Energy Laser

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: JPM LW155/PM Crusader

OBJECTIVE: Design and build an innovative high-energy laser device suitable for use as an ignition system for Large Caliber guns.

DESCRIPTION: This effort would seek to develop a method by which a single high-energy beam could be generated and be comparable to a coherent, high-brightness beam of 3 – 6 mm diameter and 1400 – 3500 W/cm2 power density. New and innovative methods of creating this high-energy laser beam are to be explored. One possible method is to look at combining low energy laser beams as generated by numerous diode emitters into a single coherent high-energy laser beam. The use of a more efficient means of energy conversion, such as a diode laser, would offer benefits over a solid-state laser by reductions in weight, size, cost, and power consumption. 30 and 60-Watt diode lasers have been demonstrated to be capable of igniting large caliber gun propelling charges and withstanding a harsh shock environment of up to 400 g's on a 155mm Cannon Breech. The ignition delay associated with a diode laser as an igniter, however, has been demonstrated at 200 – 1700 sec, which is unacceptably long and variable. An ignition delay of up to 250 msec with 10% variability is required. High-energy diode lasers employ multiple diode emitters to generate high total energy. However, current methods for bundling and coupling multiple emitters result in a highly divergent, low-brightness beam. Additionally, the light beam from each emitter is not in phase with those of the other emitters. This out of phase condition results in a significantly reduced level of effective power incident on a target.

PHASE I: Design a high-energy laser including functional diagrams, analyses, and hardware specifications to identify performance predictions and power conversion efficiencies.

PHASE II: Develop a prototype system and perform proof-of-principle demonstration of high-energy, high-brightness laser beam.

PHASE III: For military applications, the high-energy laser is being pursued for armament ignition systems, specifically for the 155mm Cannon. Commercially, this high-energy laser will have manufacturing applications such as welding and cutting of metal parts. Both applications have similar high-energy requirements and harsh environments.

KEYWORDS: High-energy Laser, High-energy Diode, Laser Ignition

REFERENCES:
1) Beyer, R.A., and Reeves, G.P. "Laser Ignition Threshold for Black Powder." The 37th JANNAF Combustion Meeting, CPIA Publication 701, vol. 22, 2000.
2) Chang, L.M., S.L. Howard, and P.Y. Hiu. "Laser Ignitability of Some Candidate Igniter Materials for Black Powder Substitute." ARL Technical Report ARL-TR-2057, September 1999.

A01-006 TITLE: High-Power Acoustic Source

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PM Mines, Countermines, Demolitions (PM MCD)

OBJECTIVE: Design and build an acoustic source capable of directional transmission of high levels of acoustic energy. Small size, low cost, directionality, range, and power handling capability are of great importance. Source can have a broad frequency range or be optimized for a specific audible frequency.

DESCRIPTION: Recent advances in our understanding of how human beings react to acoustic energy have lead to the development of several directed energy weapon concepts. However, current speaker or piezo technology has not progressed to the power handling and output levels desired to achieve meaningful effects at a distance greater than 10 m. The current effort is to develop a directional, high-power source of acoustic energy for incorporation into a variety of systems.

PHASE I: Develop a theoretical design for the new acoustic source. Develop a mathematical model to demonstrate the expected output and range for a given input signal. Provide a trade-off study showing the relationship between the primary desirables of small size, low cost, directionality, range, and power handling capability.

PHASE II: Develop and demonstrate a prototype source in a realistic environment. Conduct testing to determine the range, directionality and output power of the source, as well as the upper limits of its power handling capability.

PHASE III: This system would have wide utility in both military and civilian applications. Long range, high power acoustic sources could be used by local law enforcement for crowd control/communication, as well as in any number of civilian applications. Sporting events, outdoor ceremonies of any type, and alarm system audible alerts are all possible applications. Any situation that would benefit from a long-range, high-power capability audio source would benefit.

REFERENCES:
http://www.acoustics.org (over 1000 searchable reports dealing with acoustics may be found at this website)

KEYWORDS: Acoustics, speaker, piezo, energy, directed energy

A01-007 TITLE: Recovering Energy from Small Caliber Gun Barrel Firings

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Small Arms

OBJECTIVE: Design and build a functional electrical power source that utilizes the waste energy from small caliber gun firings

DESCRIPTION: More electrically powered devices (e.g. optics, thermal IR imaging, rangefinder, etc.) are being placed on infantry small caliber rifles for enhancing and sustaining their war fighting capabilities. An increased logistic burden is being placed on the soldier to maintain the operational capabilities of these add-on power devices. To lessen this burden, it is envisioned that an electrical power source be devised that harnesses the waste energy expended during the firing of the weapon. Typically, approximately 30% of the chemical propellant energy is utilized to provide the kinetic energy to the round; the remaining propellant energy is converted to either thermal energy to the gun barrel or thermal energy and kinetic energy to the expelled propellant combustion gases. Under these circumstances an energy harnessing material/device can be appropriately positioned to recover some of this waste energy, store it for future use to power devices or recharge batteries. The target system weight is 100 grams. Added features desired is the ability to know when the system is ready to provide power, when a malfunction exists, the ability to change mode of charging (i.e. trickle or quick) and the option to provide power on auto mode or with the manual use of a retractable power line.

This effort will define and assess maximum stored energy values commensurate with various sustained gun barrel-firing levels in typical operational warfare scenarios. Devise a methodology and design means for transferring the stored energy to soldier carry devices needing electrical power. Characterize the ability of the proposed system to sustain the functional performance of electrically powered items on gun barrel or carried by soldier.

PHASE I: Design an energy recovery system able to act as an electrical power source to charge batteries used by the infantry soldier without sacrificing gun barrel performance or significantly increasing soldier carry weight. Model the operation of the system and provide simulations to characterize performance under various field situations.

PHASE II: Build a breadboard prototype that will establish the proof of concept in a simulation of a typical battlefield war-fighting scenario. The energy harvesting and storage system will undergo weaponization into an appropriate small caliber infantry weapon. Consideration should be given in the design to such factors as robustness, sustainability and durability. It should also be compatible to the form-fit-function of the present gun barrel so as not to degrade its performance.

PHASE III: The development of an efficient compact waste energy-harvesting device will have broad commercial and consumer applications. Since it will be designed to deliver safe, clean, environmentally friendly, inexpensive renewable electric power it can be utilized in a diverse assortment of electronic and military communications equipment. What needs further development is adapting to other waste energy sources besides gun barrels. These sources can be as diverse as waste energy from internal combustion engines, the human body, or the ambient environment (e.g. fluid motion, solar).

REFERENCES:
1) STAR 21, Strategic Technologies for the Army of the 21-Century, National Academy Press, 1992
2) Energy-Efficient Technologies for the Dismounted Soldier, National Research Council, 1997
3) Handbook of Weaponry, Rheinmetall GmbH, 1982
4) Fact Sheets on specific weapon systems: see www.fas.org (site index- U.S. Weapon Systems)
5) Technical Manuals for each weapon system: see www.ntis.gov (search keywords: M240, M249, M16)

KEYWORDS: waste energy, small caliber gun barrel

A01-008 TITLE: Wireless Sensor/Actuator Communications for Advanced Munitions and Weapon Systems Operating in Harsh Environments

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems

OBJECTIVE: To develop new wireless technologies for the next generation of advanced weapon systems and platforms which will make possible the integration of embedded wireless sensors, multi-channel wireless technologies and electronic packaging that is configurable to the geometry of the host structure.

DESCRIPTION: The next generation of advanced weapon systems and platforms, such as the Future Combat System Multi-Role Cannon and Munition Suite, will require embedded wireless sensors and actuators with communication/command capabilities that will enable the elimination of physical wiring between sensors, processors and communication devices. Sensor and actuator systems will be used in a distributed fashion in which the information from numerous independent systems is wirelessly communicated to a centralized location within the munition. This information is then transmitted to a base location such as the weapon host platform or field communication/command location. Essentially, arrays of sensors and actuators integrated within the munition can be networked to a central point within the round. Furthermore duplex communications capabilities between the smart materials and this central point will provide the capability to monitor the behavior of the smart materials and also provide controlling signals to the materials through the duplex wireless links. This effort will take advantage of ongoing work being performed in the areas of intelligent wireless MEM (micro-electro mechanic) sensors, spread-spectrum transmission technology and smart sensor networks. Embedded wireless sensing capabilities in conjunction with state-of-the-art multi-channel digital data communications will eliminate physical wiring throughout the internal microelectronic sub-systems of munitions.

PHASE I: Develop concepts and communication protocols to implement communication of sensor and actuator information in noisy and cluttered environments. Determine technologies necessary to implement next generations embedded wireless communication networks with multi-function capabilities to communicate real-time information to a centralized location within the smart munition or the weapon platform. The internal network will also have the capability to communicate between sensors, actuators and also will be capable to store information for onboard processing.

PHASE II: Develop the concepts from Phase I into a prototype which integrates new wireless technologies and communication protocols into the Army multi-role cannon of the Future Combat System.

PHASE III: The development of embedded wireless RF sensors and communications networks and protocols for Munitions in Harsh Environments is quite appropriate for modern communication systems. Widespread use of these technologies will be applied in the automotive industry, in the cellular communications industry and the jet engine development and manufacturing industry. Wireless technologies developed in phase 1 and phase 2 can also have enormous impact in wireless web and associated applications. These new technologies will result in very high levels of functional integration and electrical speeds that will support multi-functional RF domain circuitry readily implemented in silicon die. Technologies proposed will have other multiple applications in existing weapon platforms such as replacing outdated expensive slip-ring technology that currently is used to interconnect digital data and video in rotating platforms such as tank turrets.

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1) Monolithic Miniaturized Telemetry System. Carlos M. Pereira, US Army Research Development & Engineering Center. INTERNATIONAL TELEMETRY CONFERENCE, 1993 VolumeXXIX, page 243
2) A Monolithic High-g Telemetry Transmitter. D. Ferguson, D. Meyers, P Gemmill, C Pereira. US Army Research Development & Engineering Center Honeywell Systems and Research.
3) INTERNATIONAL TELEMETRY CONFERENCE, 1990 VolumeXXVI, page 497
4) Intelligent Sensing and Wireless Communications In Harsh Environments. Carlos M. Pereira, Michael S. Mattice, Robert Testa. US Army Research Development & Engineering Center. Smart Structures and materials 2000.
5) Smart Electronics and MEMS. The International Society for Optical Engineering. 6-8 March, 2000, Newport Beach, California

REFERENCE SPECIFICATION: Future Combat System Multi-Role Armament Smart Cargo Projectile proposed characteristics:
Length 800mm
Weight 18kg, Lightweight materials
Diameter 105mm, Maximize payload volume
G load approximately 20,000 G's
Range 4-50 km, Stability and Maneuverability

KEYWORDS: embedded sensors, actuators, wireless communications, MEMS, spread spectrum transmission technology, multi-channel digital communications

A01-009 TITLE: Real-Time Gun Barrel Condition Monitoring for the Future Combat System

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems

Objective: Design and develop technology to enable real time condition monitoring of the Future Combat System (FCS) armament gun barrel to identify and quantify the propagation of low-cycle fatigue cracks, bore erosion, and other conditions relevant to the life of the barrel.

Description: Direct monitoring of the barrel health will provide two primary benefits to the FCS: first, the design of the gun barrel will no longer need to assume the worst case scenario, therefore the design may focus on maximized performance as opposed to maximum life; second, the real time barrel condition monitoring system may estimate remaining barrel life, based upon the effective zones of the rounds anticipated to be fired. Gun barrel monitoring will also aid in the assessment of damage inflicted upon the gun barrel by actions other than firing. For example, striking objects such as trees, rocks, concrete walls, street signs, etc. is not uncommon while concurrently slewing the turret and outmaneuvering enemy forces. With the unprecedented burst speed envisioned for the FCS (100KPH) damage to the gun barrel may become common. If not identified, barrel deformation from such damage may result in catastrophic failure modes, including in-bore detonation of explosive rounds. The technology selected will have to provide reliability and real-time diagnostic monitoring of the health and remaining life of the gun tube. In the case of ultrasonic guided wave techniques, which could be amenable to this requirement, rugged sensors to survive field use, would have to be mounted on the tube and be able to examine the whole tube with specific emphasis on vulnerable areas. Joseph L. Rose, Cambridge Press, 1999, discusses ultrasonic guided waves for various test specimen configurations in "Ultrasonic Waves in Solid Media".

PHASE I: Study and propose a technology that will enable real time condition monitoring of armament gun barrels in all anticipated military environments (-65 F to +165 F) and demonstrate its viability for application. Provide analysis for proposed technology and risks associated with its implementation.

PHASE II: Develop hardware and demonstrate systems performance on a 105mm or larger gun tube. Conduct testing to confirm theoretical results.

PHASE III: The technology/system developed will be applicable to real time inspection of any hollow cylinder for cracks and wear. This will have widespread application in the commercial sector.

REFERENCES:
1) Gazis " Three Dimensional Investigation of the Propagation Modes for Hollow Circular Cylinders". Journal of Acoustic Society of America, Vol. 31, No. 5 May 1959, pp. 568-578.
2) J.R. Rose, " Ultrasonic Waves in Solid media", Cambridge University Press, 1999.

KEYWORDS: Gun Tube, Gun Barrel, Ultra reliability, lethality, Inspection, Condition monitoring, Future Combat System

A01-010 TITLE: Innovative Inertial Navigation System for Large Caliber Indirect Fire Artillery

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Mortars

OBJECTIVE: Develop and produce a highly accurate, compact and durable Inertial Navigation System to be used for the aiming and pointing of large caliber, indirect fire artillery cannons with technologies such as Microelectromechanical Systems (MEMS). The system will be durable for field combat, and deliver unmatched accuracy. It will be small and discrete which will allow for multiple placements for increased precision.

DESCRIPTION: Current Inertial Navigation Systems (INS) that are used on existing artillery and mortar systems are effective, but lack the accuracy and durability needed for a precise system. The main problem is that they are large in volume and are bulky. They are not durable enough for the artillery and mortar systems that are used on the battlefield. Most inertial navigation systems are using ring laser gyroscopes or fiber optic gyroscopes. Shock values of 15,000 g's and higher can be seen on an artillery weapon from gun shock. Gyroscopes are very sensitive in high shock environments, so they must be placed carefully and isolated from shock. Accuracy is lost from mounting to shock isolators and when special brackets are used. Little variations in placement of the INS unit can result in costly errors in accuracy. An important specification when it comes to inertial

navigation is drift rate, an error that propagates with time. The drift rate of the current systems is adequate, but much greater accuracies are needed. An objective drift rate for a tactical system would be less than 0.2 mils/hr. The current systems are effective, but lack the accuracies that are needed for precise aiming and pointing. Designing a small, tactical grade INS will give the extreme accuracy needed for an artillery cannon or mortar barrel. The use of MEMS would be an ideal solution for this. MEMS are very strong and durable due to their extremely small size. An objective size could hopefully be less than 2 in3. A small INS would allow for an array of sensors on the gun tube. This will give a numerous amount of readings to average and help give an extremely accurate location and direction. An accuracy of 0.5 mils is an objective design. Integration with a Global Positioning System (GPS) will also enhance the accuracy of the system. GPS calibrates and periodically updates the INS. INS allows for faster GPS acquisition and reacquisition if the signal is lost. It also improves the dynamic operation and resistance to jamming. The marriage of these two systems improves reliability and gives greater accuracy. Response time is an important specification as well. Time is of the utmost importance on the battlefield. If an inertial system is slow, there will be a delay in communication which is unacceptable. An inertial system must have a quick startup time and quicker response time to point the gun as quickly and efficiently as possible. These times would have to be in the microseconds to be effective. The electrical/mechanical interface is important as well. The ease of compatibility with the weapons other tactical systems is essential for the most reliable and accurate results. Newer technologies must be looked at to fulfill the need for this durable and accurate system. Technologies such as MEMS can give the INS excellent durability that far surpasses existent systems.

PHASE I: Design a new inertial navigational system using state-of-the-art technology such as MEMS. The new design should meet the specified parameters of durability, accuracy and volume. It should match or exceed accuracies equivalent to those on current ring laser gyroscopic systems.

PHASE II: Develop prototype of the new Inertial Navigational System. Integrate INS with GPS for more accurate readings and demonstrate in lab environment.

PHASE III: For military applications, integrate the Inertial Navigation System in a current or future artillery gun and demonstrate and test in the field. This technology also has many applications outside the realm of artillery, from backpack units to automobiles. This system can be used in conjunction with handheld GPS receivers for both commercial and personal use because of its versatility and durability. Automobile companies could use it in low cost navigational systems. With the low cost and robustness of MEMS, and its small size, GPS/ INS receivers will be affordable and very practical for anyone to own.

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2) http://www.ida.org/mems
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4) Kaplan, Elliot D. ed. Understanding GPS: Principles and Applications. Artech House Publishers, Boston. 1996.
5) Logsdon, Tom. Understanding the NAVSTAR. Van Nostrand Reinhold, New York. 1995.
6) MIL-STD-810E, Environmental Test Methods and Engineering Guidelines. 14 July 1989.
7) TOP 3-2-050, Testing of Mortar Systems. 2 April 1993.

KEYWORDS: Inertial Navigation, MEMS, Pointing and Aiming, GPS

A01-011 TITLE: Hyperspectral X-ray Industrial Imaging

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems

OBJECTIVE: Develop an x-ray radiographic system consisting of a large two dimensional pixilated array detector in which each pixel is attached to a multi-channel analyzer (MCA), so that the data output is the spectrum of x-rays impinging on each pixel.

DESCRIPTION: Cadmium zinc telluride (CZT) is the x-ray sensor of choice for non-destructive inspection imaging applications because of its mechanical qualities, high x-ray absorption, and fast throughput. Monolithic arrays are necessary for ultra-fast hyperspectral x-ray imaging. Large pixilated monolithic CZT crystals for performing x-ray detection are now available. This solicitation is for implementation of the arrays in a system performing multi-channel analysis (MCA) at each pixel to determine the energy of the individual photons seen by each pixel. To be useful for the various applications described below: the throughput of each pixel in the array should approach two million photons per second; energy resolution should be greater than seven percent at 120 KeV, arrays need to large, pixels need to be sub-millimeter in diameter; and pixel depth needs to be sufficient to have a high absorption of 200 KeV photons. The system output should be a three dimensional data array consisting

of the number of photons within the particular energy bands of the MCA as coming from each pixel, i.e., photon count per each pixel array location and energy bin.

PHASE I: Build a small brassboard system from a single monolithic array of approximately one-inch square with millimeter pixel resolution. The brassboard system should be built from off-the-shelf components – CZT array, preamplifiers, and multi-channel analyzers interfaced to a small computer. The brassboard shall be delivered to the government for experimental prove-out prior to completion of Phase 1. Design the circuitry for a large area detector for fabrication in Phase II.

PHASE II: Fabricate a system of sub-millimeter pixilated crystals to make up a large area detector. Simulate and fabricate the electronics to meet the objective. The electronics should be directly connected to the backside of the array. The electronics should include preamplifiers for each pixel, multi-channel analysis and photon counting for each pixel. The system will include computer readout and display of the data.

PHASE III: Such devices have broad application in x-ray spectroscopy, imaging of gamma radiation sources, non-destructive inspection field, the medical diagnostic field, and the detection of illicit substances. DoD applications include all standard x-ray and gamma ray inspection techniques (especially inspection of munition items), medical diagnostic procedures, and multi-spectral x-ray imaging which is just evolving, Compton cameras for detection of radioactive material, inspection of munitions, inspection of closed containers, illicit substance detection. CZT in the battlefield will be the sensor of choice for detection and imaging of radioactive material. For example, Compton cameras are used for finding small volumes of radioactive material. Non-DoD applications are even greater in number than DoD and parallel DoD applications.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: There exists certain inspection and process control operations in the manufacture of munitions which can not be adequately monitored by current inspection technology. The results are operations going out of control before the operator realizes it. Some of these processes could be adequately monitored by the system being developed by this SBIR. Cost savings will be gained when the inspection processes are adequate to measure the process requirements during the process. An examples is where both the chemical composition and density of material is of prime importance, such as in hand grenade fuse manufacture. Numerous other examples exist.

REFERENCES:
1) Martin Clajus, et. al., "Scanned X-Ray Images from a Linear CdZnTe Pad Array with Monolithic Readout Electronics," SPIE Imaging Spectrometry VI, July 2000
2) Tumer, T.O., Joyce, Yin, P.D. Willson, Parnham, & Glick, "Preliminary Results Obtained from Novel CdZnTe Pad Detectors," IEEE Transactions on Nuclear Science, V43, No 3 (Jun), p1417-1421, June 1996.
3) Peng, .Tumer, Petrini, Kravis, Yin, Parhan, Glick, P.D. Willson, "Preliminary Results from a Novel CdZnTe Linear Pad Detector Array X-ray Imaging System," Presented at SPIE Symposium on Hard X-ray/Gamma-Ray and Neutron Optics, Sensors, and Applications, Proc Vol 2859, p 319, Aug 1996.

KEYWORDS: cadmium zinc telluride, x-ray detectors, sensors, inspection, x-ray, and medical diagnosis.

A01-012 TITLE: Single Chip Micro Electrical Mechanical Systems (MEMS) Environmental Sensor Suite

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO-Ground Combat And Support Systems

OBJECTIVE: Design and develop a low cost multi-sensor "suite" consisting of 3-axis shock, temperature, and humidity sensors all operating on a single microchip.

DESCRIPTION: To ensure that only fully functional, "ultra-reliable" munitions move forward through the distribution system to the warfighter, the environmental conditions that munitions have been subjected to throughout their lifetime need to be monitored. Knowledge of the environmental conditions associated with storage, transportation, and field deployment is a critical precursor to determining overall munition "health" status. It is known that certain components are sensitive to shock, humidity, and temperature extremes for example. The duration and severity of these exposures are degradation "drivers". Accelerated aging studies conducted during the development cycle deliberately subject items to environmental extremes so that inherent susceptibilities become known. From these studies, models can be generated that will enable determination of the condition status of a munition based on its actual environmental exposure history over time. To date however, the Army has not had a low cost device that could track the complete environmental exposure history of munitions. The sensor suite sought under this SBIR topic will be a key enabling technology for such a device. It will subsequently be integrated with a power supply, microcontroller, and memory into a small package. An environmental sensing/monitoring device that is an integral part of a

munition or its associated packaging must be low cost, small (ideally approximately .75" X .75" X .10" or less), and use very minimal amounts of electrical power so that operation can be ten years and more from a small power supply (batteries). Integrating multiple sensors on a single chip using Micro Electrical Mechanical Systems (MEMS) fabrication technology is considered to be the optimal way to achieve these objectives vs. multiple discrete devices. This technology will help support a lighter force by ensuring that only ultra-reliable munitions reach the warfighter.

PHASE I: Generate initial designs for the single chip integrated sensor suite with the following performance objectives:
Temperature: -50 to +165 degrees F
Humidity: 10 – 95 % RH (+/- 6%)
3 Axis shock: up to +/- 500 g's (+/- 5%)
Operation to be at 3 volts, with a focus on absolute minimization of power consumption. An analysis of the power level required to operate the device shall be provided with the offeror's proposal. Ultimate cost objective is under $6/unit for production quantities.

PHASE II: Finalize designs initiated in Phase I and commence fabrication of prototypes for test and evaluation against stated performance requirements.

PHASE III: This sensor chip could have applicability to a number of DOD systems besides munitions, such as vehicles, launch platforms, sensitive electronic equipment, food and medical supplies etc. Likewise, in the commercial sector, similar items could be monitored for spoilage or shipping related damage, enforcement of warranties, etc.

REFERENCES:
1) http://www.mems.isi.edu/
2) http://www.mems-exchange.org/

KEYWORDS: Sensors, microchip, MEMS

A01-013 TITLE: <u>Reduce Diameter Hi-Power RF-Antenna</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Mines, Countermines, Demolitions (PM MCD)

OBJECTIVE: Design and build a high powered three-dimensional RF antenna that is portable and can be deployed in Urban environments, function while unattended, capable of continuous firing over wide fields of view, and capable of delivering very high amounts of directed energy

DESCRIPTION: The traditional method to increase the gain and directionality of an RF antenna is to increase the diameter of the dish. However, using this method to achieve the gain and directionality required for a directed energy weapon system would result in an unacceptably large diameter dish. The goal of this effort is to explore the feasibility of trading off some of the dish diameter for depth, i.e. turning antenna design from a 2-D problem into a 3-D problem.

PHASE I: Develop a theoretical design for the high power RF antenna. Develop a mathematical model to demonstrate the expected gain and radiation pattern. Provide a trade-off study showing the relationship between the primary desirables of small diameter, low cost, directionality, range, and power handling capability.

PHASE II: Develop and demonstrate a prototype system in a realistic environment with Army-supplied samples of possible targets. Conduct testing to provide feasibility over extended operating conditions.

PHASE III: This system would have wide utility in radar and communication areas. Such an antenna could increase survivability of radar and communication units by proving a smaller target size. A reduced diameter, high gain, directional antenna would also benefit the commercial sector by allowing the use of lower power transmitter. Lower power transmitters should also reduce the exclusion zones associated with high power antennas.

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1) Staelin, David H. Electromagnetic Waves. ISBN: 0-13-225871-4
2) Pozar, David M. Microwave Engineering. ISBN: 0-201-50418-9

KEYWORDS: Directed energy, 3-dimensional Array, Antenna

A01-014 TITLE: Integrated Configured Load Building Decision Aid

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems

OBJECTIVE: Develop intelligent agent and decision aid technologies for munitions handling operations that will reduce the labor hours currently required to build Mission Configured Loads. These technologies will provide an intelligent interface and data prioritizing schemes between the various ammunition tracking systems. The target application will enhance asset visibility and increase the distribution velocity of ammunition shipments through the in-theater storage areas to the combat users while reducing manpower requirements of in-theater operations.

DESCRIPTION: Recent advances in intelligent agents, distributed object based computing and high-speed PC based processors have made possible an over-arching system capable of optimizing the entire in-theater ammo handing operation. These developments can be extended to develop a PC-based intelligent agent decision aid interfaced with Standard Army Ammunition System (SAAS-MOD), Ammunition Surveillance Information System (ASIS) and Global Combat Support System-Army (GCSS-A) providing an adaptive environment to generate optimized build procedures. This system will coordinate inputs from the various information databases, creating the desired munitions content of the load and compare this with what munitions are available throughout the specific field storage site. The system will then produce an ordered checklist of what items are to be gathered, where they are placed on the trailer or flatrack and how they are secured with banding or strapping. The ordered checklist will be derived by cross-referencing the desired munition quantities with availability and then generating an optimized path plan through the storage area. The technology developed to meet this need will include intelligent agent based planning, scheduling, optimization and plan-monitoring algorithms. Technical issues of interest include MMI, task visualization, voice natural language interface for control, modeling, knowledge based task automation, path planning, navigation and ability to automatically determine position and orientation of payload and generation of operator queues for proper positioning of the payloads. This system will operate on a COTS laptop type computer and maintain compliance with all JTA and DII COE mandates for interoperability.

PHASE I: Develop software architecture and algorithmic approaches for all data collection, embedded sensor technology, data processing and user interfaces. Perform throughput modeling and simulation studies to determine performance characteristics of the search algorithms, real time processing and system interoperability requirements. Provide analysis for evaluating system performance and provide architecture design and system hardware specifications.

PHASE II: Develop intelligent agent planning and query software components, hardware/software architecture, development environment and simulations for building and modifying a munitions loading decision aid system. Demonstrate information throughput between this system and other STAMIS (Standard Army Management Information Systems) applications. Demonstrate system performance capabilities in an ammo handling field experiment using test scenarios designed around mission configured load requirements. Provide prototype system with operators control station, documented source code, development environment and complete operators manual suitable for training non-technical personnel for evaluation exercises.

PHASE III: The technology developed under this program can be applied to any data warehouse or data mining operation to extract pertinent information. This system will provide an optimized plan for the loading of any large container system reducing the man-hours required for typical loading operations. This technology is also applicable to automated warehousing, railhead and port operations.

REFFERENCES:

1) The Global Combat Support System-Army, (GCSS-A), Architecture: http://gcss.jsj4.com/gcssoa/index.html

2) Standard Army Ammunition System- Modernization, (SAAS-MOD): http://www.cascom.army.mil/automation/automated_systems/standard_army_ammunition_system/Standard_Army_Ammunition_System-Modernization.htm

3) Program Executive Office Standard Army Management Information Systems, PEO STAMIS: http://www.peostamis.belvoir.army.mil

KEYWORDS: intelligent agent, software architecture, interoperability, decision aids, user interface.

A01-015 TITLE: Intelligent Multi-Agent Hybrid Systems Control Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Mines, Countermines, Demolitions (PM MCD)

OBJECTIVE: Develop algorithms, design methodology and processing architectures to support implementation of real time multi-agent and hybrid systems control technology for coordinated, rapid response, multi-target/ multi-platform future combat netted fire control applications. Demonstrate and validate technology for distributed fire mission engagement.

DESCRIPTION: Recently progress has been made (see ref) in developing hybrid/multi-agent processing algorithms, design methodology and architectures to support distributed intelligent decision making, planning and real time control which makes feasible the design and implementation of multi-agent control strategies for coordinated multi-platform weapon engagement. Further development is required to mature this emerging technology, optimize algorithms and hardware/ software implementation architectures and validate the concept in a realistic scale engagement simulations. Key requirements of the multi-agent architecture are a) real-time performance b) reactive, event driven behavior 3) adaptive/ on-line learning based on sensory data 4) distributed decision making and coordination 5) support for multiple levels of abstraction in reasoning and control 6) distributed reasoning in the presence of uncertainty 7) information fusion 8) target track management and deconfliction and 9) design flexibility for reconfiguration to different platform mixes, mission requirements and sensor configurations. This project will address the broad spectrum of issues associated with the development of prototyping tools and design methodology, hybrid system modeling and multi-agent simulation, real time hardware/software implementation, multi-agent algorithm development, and human-computer interface.

PHASE I: Develop methodology, computational approaches and architectural concepts to support design and implementation of multi-agent hybrid system control laws for distributed multi-platform applications. To demonstrate the generic nature of the multi-agent framework and methodology adapt the problem formulation to the multi-target- multi-platform engagement application and also illustrate applicability to distributed process control and scheduling. Problem formulation should take into account physical constraints and characteristics of sensor/actuator subsystems as well as inter-platform communication and network constraints. In the case of the fire mission application, such constraints would include pointing accuracy, slew rates, rate-of-fire, sensor characteristics, tactics, etc. Phase I will formulate muti-target-multi-platform engagement strategies that optimize use of shared information and resources and maximize hit probability and engagement effectiveness and provide preliminary performance analysis. Phase I will also identify specific software development and design tools, provide preliminary concept definition and specification of implementation environment.

PHASE II: Develop a fully integrated design and prototyping environment to support generic multi-agent control applications. The design environment will include hybrid system modeling and simulation tools, and agent design and prototyping tools to support application development, implementation and testing. Develop detailed agent algorithms, application scenario, and multi-agent software and hardware prototype and evaluate via simulation. Optimize module hardware/software and algorithm design based on test data and provide complete documentation of algorithms and hardware/software architecture.

PHASE III: This work has a very high probability of commercialization. The methodology, design environment, prototyping tools and component technology developed in this SBIR are applicable to manufacturing, machine tool, process control, smart highway systems and distributed robotics. These applications are characterized by the presence of discrete event and continuous time dynamics which are tightly coupled and require hybrid design methods to ensure performance and stability. This technology also has broad DOD applications, particularly in the area of affordable controls; distributed, multi-platform fire control and targeting; intelligent, multi-agent, cooperative systems; defense manufacturing, etc. The impact of the technology is two-fold: increasing performance through improved control software while reducing cost by encouraging reuse and improving reliability, maintainability and fault tolerance.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Multi-agent processing technology will permit optimal utilization and distribution of assets on the battlefield as well as reduce training and personnel requirements by enhancing automation of crew functions.

REFERENCES:
1)Multiple agent Control For Manufacturing Systems, Proc.IEEE International Sym on Intel Control
2) Scalable Data and Sensor Fusion Via Multiple Agent Hybrid Systems. IEEE Trans on Automatic Control, Spec Issue 1997.
3) Hybrid Knowledge Bases, Trans on Knowledge and Data Eng. 1996.
4) Adaptive Probabilistic Networks With Hidden Variables, Machine Learning, 1997.
5) Conflict Resolution For Air Traffic Management Systems: A Study in Multi-Agent Hybrid Systems, IEEE Transactions on automatic Control, Spec Issue 1997.
6) Learning Controllers For Complex Behavioral Systems, ERL Memo UCB/ERL M96/73, UC-Berkeley, Dec 1996.
7) Lecture Notes in Computer Science, springer-Verlag, 1996.

KEYWORDS: Hybrid Systems, Control Technology, Multi-target, Multi-platform, Future Combat, Fire Control

A01-016 TITLE: Multi-Purpose Portable Measurement Device

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO-Ground Combat and Support Systems

OBJECTIVE: Develop a small scale measurement device that could be used to take quick, accurate, measurement of critical munition dimensions, compare the readings against item specifications and give a quick go/no go. Device would be portable to facilitate field use.

DESCRIPTION: Design and develop a system that can be easily used and readily tied to specification databases, even when operating at remote locations. Laser, acoustic, RF or other measurement technology could be utilized. This technology would eliminate maintenance and administrative overhead of a whole range of gages in favor of a single computerized tool, reduce wear and tear on items gaged and permit gaging items in the field. The device could tie to specification databases to improve operator measurement efficiency. This new technology would allow more rapid and accurate assessment of materiel condition to accelerate delivery of critical munitions throughout the logistics system on a moments notice in support of short re-supply cycles. The device will improve user survivability and lethality and reduce the logistics re-supply burden by assuring only the most serviceable assets are sent forward. The system will have to demonstrate accurate measurement capability, ease of use in a field environment and have no adverse affect on the total logistics system. The solution has to be simple and lightweight and capable of measuring all current and future munitions that require gage measurement.

PHASE I: Develop initial design for a multi-spectral system capable of measuring all aspects of current and future munition systems (Ring, chamber, profile and alignment, etc.) from 5.56mm through 8" projectiles within currently defined tolerances. Gaging requirements are contained in SB 742-1. Individual dimensional tolerances are contained in engineering drawings available on the JEDMICS and ASIS systems. Design should consider the potential for an interface between the measurement device and a gage specification database. This interface should allow links to both standalone (PC/Laptop, etc.) and network gage databases. Investigate applicability of Multi Purpose Portable Measurement Device to systems outside the munitions arena (Weapon, vehicle, etc.).

PHASE II: Develop hardware and demonstrate device performance on a broad sample of priority I munition item ammunition dimensional tolerances. These values are contained in the ammunition engineering drawings available on the JEDMICS and ASIS systems. SB 742-1, Appendix E, section E-3 lists small arms gaging requirements. Tables E-2, F-1, G-1, H-, I-2, J-1, K-1, L-1, N-2, T-1, U-6, Y-3, Z-4, AA-1 identify existing test and measurement equipment and requirements. The system must be easily deployed, environmentally sound and easily operated with minimal weight and volume characteristics. The prototype will be tested against existing gages & measurement devices to demonstrate and validate its capability and calibration viability. The material/technology used must be compatible with explosives and propellants and be easy to assemble/disassemble and calibrate. Provide analysis for proposed technology and risks associated with implementation.

PHASE III: The technology/system developed will enable precision measurement of a wide variety of items in commercial manufacturing enterprises in the automotive and aerospace industries. Precision measurement of non-munition items within the military arena is possible as well.

REFERENCES:
AR 750-43, TB 43–180, SB 742-1

KEYWORDS: Reduced logistics footprint, reduced life cycle costs, optimize resources, enhanced re-supply, lethality, enhanced survivability, easily deployable, light weight, field use.

A01-017 TITLE: Reusable, Adaptable and Scalable Decision Aids Components for Future Combat Weapon System Applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Mines, Countermines, Demolitions (PM MCD)

OBJECTIVE: Develop real time algorithms, design methodology and development tools to support rapid prototyping and implementation of reusable, embedded decision aids components that will provide the basis for developing the next generation of intelligent, network centric fires management and control software for Future Combat System applications.

DESCRIPTION: Rapid advances in artificial intelligence, information processing, distributed processing and software engineering technologies now make possible the automation and intelligent aiding of many time critical and mission critical combat tasks which the mounted warfighter/ commander must perform to successfully accomplish his mission on the future digital battlefield. Specifically, decision aid prototypes have been developed to support movement planning and terrain analysis using digital map data. Further technology development is required, however, to develop a repository of high capability decision aid components that can be easily adapted, configured and tailored to meet the full range of requirements for netted, effects based fires mandated by the Future Combat System. This topic will focus on the specific requirement to rapidly process multi-platform targeting data, and perform optimal assignment and scheduling of fires to maximize effects within constraints on resources, terrain, mobility and communications. Specific decision aiding capabilities of interest, in addition to movement planning, include: fire mission planning/replanning, sensor/weapon placement, sensor/information fusion, situational awareness, event monitoring and alerts, self defense, course-of-action analysis/prediction, sustainment, diagnostics/prognostics, etc. Highly modular architectures must be developed to facilitate reuse of application software and provide a basis for component based assembly and evolutionary growth in software capability to meet evolving requirements. Implementation architectures must also address interfaces with embedded C4I,MMI,and NIMA terrain data bases and conform to emerging weapon system Technical Architecture and distributed object computing standards. Efforts should exploit emerging object oriented tools and technology, visualization technology, voice processing, artificial intelligence and information processing technologies, etc. to maximize performance and functionality, enhance MMI capability, reduce development cost and facilitate component integration and testing in a network environment. Proposals may address development of one or more reusable decision aid application components and must provide the domain engineering expertise required for prototype demonstration.

PHASE I: Develop algorithm approach and design concept and formulate preliminary development and implementation approach. Develop top level architecture specification and identify tools and methodology that would be applied in Phase II to support application component development.

PHASE II: Develop a detailed knowledge base, application scenario, scenario driver, reference architecture design model, tool environment and component API specification. Develop and implement one or more decision aid application components to demonstrate and validate component functionality and demonstrate component reuse potential. Optimize hardware/software, algorithm and interface design based on laboratory test results and provide complete documentation of hardware/software, analysis and test results.

PHASE III: This work has a very high probability of commercialization. The methodology, design environment, prototyping tools and component technology developed in this SBIR are applicable to online embedded decision aids for commercial piloting systems, ground vehicle navigation systems, commercial warning and alerting systems, embedded diagnostics and prognostics for commercial equipment, health monitoring and diagnostics and decision aiding for law enforcement applications.

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3) J.W. Guan, and D.a. Bell, Evidence Theory and It's Applications, vol 1. Studies in Computer Science and Artificial Intelligence, Elsevier, North Holland, 1992.
4) P. J. Antsaklis, and A. Nerode, Special Issue On Hybrid Control systems, IEEE Trans. Automatic Control Systems, No. 4, Vol. 43, Apr 1998.
5) D. Koller and A. Pfeffer, Object-oriented Baysian Networks, Proc. Of the 13th Annual Conf. On Uncertainty in AI, Aug 1997.

KEYWORDS: Sensors, video surveillance, tracking, vision system, pattern analysis

A01-018 TITLE: Innovative Particle Separation Method for Metal Nano-powders

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Small Arms

OBJECTIVE: To develop an innovative method to separate nano-sized particles. Design, build, and demonstrate a device capable of separating spherical or non-spherical metal powders having a size of 20 to 200 nanometers. Method must be capable of separating powders to an accuracy of +/-5 nanometers at any specified size within the aforementioned size range and at a particle separation rate of no less than 1 kg/hr.

DESCRIPTION: Nano-sized metal powders are currently being developed at the Armament Research Development and Engineering Center for use as primers, propellants, and high explosive energetic material. These metal powders have

demonstrated great potential in these applications, but no method currently exists to guarantee the uniformity of particle size. It is expected that controlling particle size uniformity and homogeneity of particle mixing will further improve performance of these metal powders. Typical mechanical methods of separation (i.e. metal screen sieves) are not feasible for such small particle sizes. An innovative method as well as equipment is required to improve the performance of these metal powders in primer, propellant, and high explosive applications.

PHASE I: Design an innovative and novel method of particle separation which will be tested in a small-scale proof of principal test. A trade-off between processes will be conducted and a single process selected for further development.

PHASE II: A prototype device will be built and tested based upon Phase I selection to perform particle separation in the range of 20 to 200 nanometers, +/- 5 nanometers and at a rate of no less than 1 kilogram per hour. The government will provide metal powders for testing.

PHASE III: Nano-powders have broad use as precursors in a number of applications to include sintering and plasma-spray forming. No method of separation currently exists for particles in this size range. A dynamic separation method would improve nano-powder products in a wide variety of medical and semi-conductor applications.

REFERENCES:
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2) 15-16 Apr 98
2) Tetronics Nanopowder Demonstration, 27 June 2000
3) http://www.barc.ernet.in/webpages/technologies/micron.html

KEYWORDS: nano-powder, nanometer, nanotechnology

A01-019 TITLE: Adaptable/ Reusable Hardware/Software Architectures and Components for Future Combat System (FCS) Automated Resupply

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: APM, SRS Prog, UGV&S JPO

OBJECTIVE: Develop a generic, multi-mission capable, reusable modular hw/sw suite and development environment to support advanced supervisory/semi-autonomous and autonomous control of multiple platforms for materiel handling, re-supply and logistics automation for Future Combat System (FCS) applications.

DESCRIPTION: Recent advances in multi-agent intelligent systems technologies, non-supervisory learning technologies, multi-sensory based perception and reasoning under uncertainty, collaborative planning, high performance robotic manipulation, visualization technology, and intelligent controls, now make possible a new generation of low cost intelligent systems capable performing re-supply functions under combat conditions without exposing friendly personnel. These technologies will permit revolutionary advances over current state-of-the-art and manpower intensive tele-operation technology. Specifically, the computer science and algorithm base for intelligent systems and supporting software development environments will permit streamlined development and standardization of intelligent software systems to permit retrofitting on a broad range of legacy platforms as well as next generation FCS robotic platforms to reduce software cost. The key technical challenge will be to fully exploit this emerging science base and provide an integrated architecture and solution approach that addresses fundamental problems of mobility and base motion effects, flexible task level control and automation, multi- sensor integration, multi-manipulator coordination associated with automated container handling and movement, autonomous re-supply, and distributed, autonomous control of multiple heavy-lift platforms, such as cranes and forklifts, necessary to automate forward re-supply point operations. Technical issues of interest include MMI, task visualization, compliant motion control, visual servo control, voice natural language interface for control, multi-manipulator control strategies, modeling, design and real time prototyping tools, knowledge based task level control and control from moving base including path planning, navigation and obstacle detection/avoidance and component based software architectures. Control approaches should also address issues related to multi-platform autonomous control, communication and coordination.

PHASE I: Develop methodology and algorithm approaches to intelligent multi-platform tele-operation and task automation for applications to materiel handling and automated logistics. Perform preliminary modeling and simulation studies to determine performance/robustness characteristics of architecture and algorithms, and assess real time processing, MMI and sensor requirements. Provide analysis for evaluating system performance potential and provide preliminary design concept.

PHASE II: Develop prototype component hardware/software and supporting development environment and interface with laboratory test bed facilities and materiel handling technology demonstrators. Develop test scenarios and mock-ups to demonstrate system prototype performance capabilities. Demonstrate fully integrated prototype module with documentation, source code, models and development environment and evaluate in laboratory and non-laboratory tests.

PHASE III: The technology developed under this program is applicable to a broad range of commercial logistics and material handling applications such as hazardous waste removal, commercial logistics, cargo loading/unloading, factory and warehouse automation, exploration, fire fighting, crime fighting, commercial bridge and high tension power line repair, etc. Topic supports key Army initiatives to increase efficiency and reduce the cost associated with sustaining the future digitized force through the development and application of advanced automation technology.

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KEYWORDS: robotic material handling, intelligent software, digitized force

A01-020 TITLE: Battlefield Acoustic Signature Analysis

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: PM Mines, Countermines, Demolitions (PM MCD)

OBJECTIVE: Design and test improved algorithms exploiting new analytical methods in expert systems, neural networks, fuzzy logic, and other state-of-the-art system level fusion techniques which lead to source separation in complex multiple source environments. Such algorithms will be integrated and tested as part of a network of unattended acoustic sensors capable of improving signature separation and classification in a noisy/cluttered, multiple target environment.

DESCRIPTION: The Army needs to use unattended passive ground sensors for battlefield surveillance, situation awareness and cueing for other sensors and weapons. As a result, advanced acoustic sensors are exploited to sense information such as target locations, target movement, target types, etc. The use of networked acoustic sensors to detect, track and classify single vehicle target in range up to 1K meters has been demonstrated. However, the detection, tracking, and classification of multiple vehicles in a target rich environment remains a technical challenge. In addition, the field commanders often want to know the size of an enemy convoy that could consist of heavy and light vehicles. The current acoustic sensor design (either individuals or networked), employing algorithms based on acoustic signature characteristic such as the engine firing rate (EFR) and sound pressure level (SPL), have difficulty in detecting, tracking, and classifying multiple vehicles when they are closely spaced (around 50m to 100m apart). The inability to detect and determine the number of targets in multiple targets scenarios would effect the field commanders' decision for fire. The use of advanced signal processing techniques such as adaptive beamforming, beam optimization, and various target counting/classification solutions are being explored to optimize the potential for a reasonable cost effective system solution for determining the approximate location and direction of a target rich environment. Reasonableness is currently defined as small sized arrays (4 ft or less) containing 8 microphones or less (5 or less desired) with total number of acoustic platforms 4 or less within a 1Km grid square surveillance area. The objective of this research is not to determine a complete system solution to the above problem but to develop an algorithm enhancement which is additive to above techniques. Based on investigation of current research, it appears that novel blind deconvolution techniques and associated algorithms can be used to determine the existence of multiple target signatures WITHIN a beam and can be used to enhance existing classification algorithms and help deal with aggravating environmental effects.

The algorithmic approach will ultimately become a module as part of a top level algorithm with the purpose of identifying the location of a tactically significant target formation, through the use of various counting, tracking, and classification sub-algorithms. The current planned test bed for the acoustic system will consist of 4 acoustic sensor arrays, each containing 5 microphones, each array 250 meters apart in a square configuration, monitoring target activity over an area of interest which is approximately 1Km X 1Km grid square and in which the surveillance duration and acoustic monitoring of targets may take place from 1 Km in front of the grid square to within the confines of the grid square.

PHASE I: Review presently employed classification and beamforming techniques and how the proposed new algorithms will build and enhance these existing solutions. Receive multiple target signature base and Matlab algorithm simulations from the Government. Provide improvements in multiple target classification by exploiting blind separation of independent sources from

their convolutive mixtures, employing maximization principles, feedback network architectures, adaptive filters, neural nets or other state-of-the-art techniques. Submit Matlab algorithm and simulation of multiple target classification improvements to the Government.

PHASE II: Integrate the improved blind deconvolution algorithm as part of the Government acoustic data acquisition and algorithm development environment and test in the field the improved multiple target identification and tracking algorithm.

Note regarding Phase I and II - Delivery and/or results of the government tests shall be shared with contractor. Contractor shall retain proprietary rights of developed algorithms for further distribution/sales.

PHASE III: Improvements in blind separation of targets and advanced adaptive algorithms are being developed for use in speech recognition applications. The potential outcome of this SBIR will be to provide a combination of improved beamforming methods with blind deconvolution technologies, leading to applications which will enable improvements in the ability to provide detailed surveillance of individual personnel in a cluttered multi-personnel environment. Such applications would include any security function, police, border patrol, and monitoring of prisons. Systems employing advanced beamforming are currently being deployed in prisons and the improvements in blind deconvolution would allow the potential to resolve individual voices in a complex and noisy multiple signature environment.

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KEYWORDS: Blind Deconvolution, blind separation, convolutive mixtures, adaptive filters, multiple targets, adaptive beamforming, acoustic algorithms, Matlab

A01-021 TITLE: Projectile Recognition System to Support Future Combat Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM Mortars

OBJECTIVE: Develop and produce an automated projectile recognition system to easily and accurately identify the inventory of an ammunition magazine containing various rounds. This system will provide information to a fire control computer regarding type of munitions, charge settings, fuze types, and where their locations are in the magazine.

DESCRIPTION: Automated projectile magazines are needed to support robotic unmanned weapon platforms, like the RAMM (Responsive Accurate Mission Module) and the Multi-Role Armament System (MRAS), which are becoming more prevalent in the upcoming Future Combat Systems (FCS) family of vehicles, as well as manned FCS systems employing an autoloader, such as the MRAS. A projectile recognition system is needed to identify an inventory of projectiles loaded into the ammunition magazine. The inventory of projectiles will contain different types of rounds with different fuzes and charges. Recognition may consist of some way to image the round and identify it by its distinguishing physical characteristics or by reading the standard markings on the exterior of the round. This system is needed to allow an automated armament system to call upon the magazine, index to the required projectile, extract and load into the gun to complete a fire mission. The key to this recognition process that there is very little user input required to manipulate the round as it is loaded into the magazine. This concept drives the requirement that the recognition system might be optical in nature. The size, shape, color, physical markings, and charge increments on a standard round must be recognized by the system to accurately identify the exact characteristics of the round. This high level of technology goes beyond a simple bar code or radio tag. Such simple recognition devices have hindrances such as needing to be placed into the magazine in a certain position by maintenance personnel to be read or a tag's inability to be read through the steel casing of the round if not oriented in a certain position. By developing a high-tech optical recognition system, it reduces and simplifies the workload for field re-supply personnel under combat conditions.

PHASE I: Design an overall concept of an inventory recognition system to identify an inventory of objects which can be categorized by specific physical characteristics as they are fed into a holding container and records their positions in the container. Provide details for how the items are to be recognized and differentiated and what information will be transferred to the inventory computer, so that the computer knows each item's critical characteristics and it's placement in the holding container.

PHASE II: Develop and demonstrate a prototype system to work in a stand alone demonstration to show the principals of the design and how the system designates different types items by their distinguishing characteristics, and tracks each item's position in the holding container for the inventory computer. The system demonstration will be required to identify a variety of items with differing features such as size, color, shape, external markings and other unique physical characteristics.

PHASE III: The desired eventual application for FCS is an objective system which is capable of handling 120 mm mortar rounds or 105 mm artillery rounds. The objective system will have to decipher what type of projectile is being loaded, be able to identify the fuze type and propelling charge increment amounts via image recognition technology. The system will be required to identify a variety of different projectile types and configurations, which have varying sizes, shapes, colors, and external markings. The identification information will be transferred to a computer to record and control the inventory of the magazine and allow the fire control software to access the necessary round to complete a fire mission. This recognition system could be applied to a commercial application such as an assembly line packaging or any automated item handling processes. This sensing feature would aid robotic applications and provide information for artificial intelligence systems without needing the inventory to be oriented in any particular position. An example of this application would an inventory process that could track available options of one component in its inventory so that the robot could pick and choose the necessary options for particular packaging configurations or final assemblies as they moved down the assembly line. The lack of a requirement of component orientation would speed and simplify packaging and assembly procedures thereby reducing cost.

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KEYWORDS: 120mm, mortar, 105mm, projectile, round, inventory, coding, indexing magazine, FCS, RAMM, MRAS

A01-022 TITLE: Fragmentation of Energetic Materials via Directed Ultrasonic Energy

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Small Arms

OBJECTIVE: Develop and demonstrate a process using ultrasonic technology to remove cast-loaded explosives (e.g., TNT, Composition B) from medium and large caliber ammunition. The ultrasonic removal will cause in-situ controlled fragmentation of the explosive material. The procedure will be used to demonstrate the safe, efficient removal and recovery of the energetic materials and recovery of the metal parts during demilitarization operations.

DESCRIPTION: The United States stockpile of unserviceable and obsolete munitions exceeds 500K tons. A significant portion of this inventory is made up of medium and large caliber ammunition loaded with TNT and Composition B (TNT + RDX). Due to environmental considerations there is currently nor is there planned TNT production in the United States in the foreseeable future. The overall TNT inventory is dwindling. There is a major thrust to reclaim and recycle TNT and Composition B from obsolete munitions. Historically, demilitarization of this ammunition has been carried out by open detonation, and more recently, using an autoclave to melt out the energetic material and separate the metal parts. The autoclaving process is labor intensive (and thus costly with operators put at some risk) and generates pink water that must be processed as a hazardous waste.

When high intensity ultrasound is applied to a liquid medium adjacent to solid material, the stress produced by "acoustic cavitation" in the liquid causes fragmentation of the material. The stress (or pressure) produced by the cavitation of the liquid is

a function of the properties of the liquid. High vapor pressure and surface tension greatly enhance the reaction. It is proposed to use these principles to develop a process to remove and recover cast-loaded explosives from the interior of projectiles. Previous research has demonstrated the feasibility of such an approach through experiments conducted on TNT and Composition B simulants. The proposed project will build on this initial work and use live energetic materials to establish a process followed by parametric studies to investigate process performance and develop and optimized pilot process.

PHASE I: Laboratory testing will be conducted to establish baseline parameters for the fragmentation of energetic materials via ultrasonic energy. Experiments will first be conducted in explosive-filled 100-ml beakers and concentrate on the sonication liquid properties and ultrasonic power effects. Methods to remove the fractured energetic materials from the solid/liquid interface and separation from the sonication liquid will also be studied. Where appropriate, computer modeling will be used to study process phenomena and evaluate parameter interactions. The extent of material heating due to input of ultrasonic energy will be assessed. A preliminary process flow sheet and material balance will be developed.

PHASE II: Based on the preliminary process developed in Phase I, a pilot scale process will be developed, evaluated, and optimized. Rate of fragmentation, yield of recovered energetic material and recycle of the sonication liquid will be maximized. Actual munitions items (e.g., 60-mm, 81-mm, and 105-mm projectiles) will be used in the pilot process demonstration, and design data sufficient to allow scale-up to a prototype demilitarization process will be generated.

PHASE III: In the area of demilitarization, this technology has application to many different munitions. In the private sector, this technology could be used in the process industries to dislodge scale, energetic material or other foreign material build-up from the interior of process piping.

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KEYWORDS: Ultrasound, explosive, demilitarization

A01-023 TITLE: Innovative Catalytic Reactor to Eliminate Red Water Pollution

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and build a catalytic reactor that can be deployed in the selective nitration of toluene for the elimination of Red Water pollution in the TNT manufacturing process.

DESCRIPTION: In the development and production of new, as well as old explosives and propellants, enormous amounts of toxic and hazardous waste materials are generated as by-products. Disposal of these toxic materials poses serious problems for the DOD operations. Novel catalysts can be used to remove these toxic waste by-products, as well as increase the yield of the chemical reactions in the synthesis of explosive and propellant molecules. Recently we have developed a lab scale process to selectively nitrate toluene to eliminate meta nitrotouene, the source of Red Water pollution in TNT production. The process could be used in the development of other energetic materials such as 2,4-Dinitro toluene. 2,4-Dinitrotoluene is also currently being used as a raw material in polyurethane industry.

PHASE I: Design an effective catalytic reactor to carry out a continuous process for the nitration of toluene in the presence of zeolite catalysts and nitric acid as the nitrating reagent.

PHASE II: Develop and demonstrate a prototype system to conduct a continuous nitration reaction of toluene and other aromatic compounds to eliminate Red Water pollution in the TNT process by selectively nitrating toluene to generate para nitro toluene. Optimize the catalytic reactivity of these catalysts by conducting relevant experiments.

PHASE III: DOD Applications: Development of TNT process without generating Red Water pollution. Development of Pure 2,4-Dinitro Toluene for propellant applications. Could be used in the development of CL-20, the most powerful energetic material in DOD community. Commercial Applications: Use of this novel catalytic reactor in the development of energetic materials will not only be cost effective but also environmentally friendly. Possible commercial applications of these catalysts include:

1) Production of p-nitro phenylbutyric acid which is an expensive pharmaceutical intermediate. (Nitration process useful for energetic materials can be applied to the nitration of phenyl butyric acid).
2) 2,4-Dinitro Toluene is the important raw material in polyurethane industry.
3) Elimination of heavy metal cations and toxic waste by-products generated in the chemical industry, since they form stable complexes with the catalysts.
4) Use in chemical weapons disposal technology, where detoxification of chemical weapons can considerably reduce the environmental and safety concerns.

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KEYWORDS: Catalysts, Explosives, Heavy Metals, Propellants, Dual Use

A01-024 TITLE: Command and Control Training in Future Combat Systems (FCS) Units with Manned and Robotic Elements

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Chief, Futures and Simulations Division, MMBL

OBJECTIVES: Design, develop and refine tools and methods that help humans manage automated systems, and especially future Objective Force commanders and staffs manage robotic systems. More specifically, this research will focus on the design and development of intelligent technologies called "interface agents" that help control subordinate intelligent agents and robotic systems to support the C4ISR (command, control, communications, computer, intelligence, surveillance, and reconnaissance) functions.

DESCRIPTION: Advances in technology will result in an increasingly diverse range of semi-autonomous robotic systems. For example, the lead concept for Future Combat Systems (FCS) is a netcentric, distributed force that relies heavily on robotic elements. Furthermore, relatively junior commanders at echelons such as the FCS cell or team (roughly equivalent in level of command to current platoons and companies) will be responsible for employing this diverse range of assets including: direct-fire systems, non-line of sight systems, all-weather sensor systems, and layered sensor systems.

Current tools and methods for managing robotic systems are generally designed for operators controlling single and/or sets of similar systems in controlled environments. Future requirements will involve multi-echelon teams of commanders, staff officers, and operators employing a diverse range of robotic and manned systems in battlefield environments. As a result, command and control tools and methods become extremely challenging. Despite the technical advances anticipated in robotics and artificial intelligence during the next decade, human management will undoubtedly be required to overcome limitations in robotic autonomy and intelligence. In the future, more powerful and less attention-demanding tools and methods for managing multiple and diverse robotic systems will be required in military and commercial domains.

The envisioned solution is an integrated intelligent interface for human management of future systems. Proposals to this topic will address research issues in the design and development of intelligent technologies called "interface agents" that help control subordinate intelligent agents and robotic systems to support the Objective Force C4ISR functions. Here, a basic distinction is drawn between informational and robotic systems. Examples of automated informational systems include "intelligent" software programs instantiated as agents or "bots." Examples of robotic systems include relatively large scale and micro robotic ground and air vehicles. Of course, for robotic systems to exhibit even semi-autonomous behavior they must include intelligent software. Design of these interface agents should target: reducing the amount of interaction between humans and systems, particularly at detailed levels, reducing management training and knowledge requirements, and supporting the human functions such as decision-making, situation assessment, and communication across and within echelons.

This effort will focus on the design of "tasking", "monitoring", and "coordinating" agents for command, control, and communication functions, respectively. Tasking agents should provide a streamlined directive interface that will allow the human commander to quickly generate multiple command decisions, and then pass those decisions to autonomous and/or semi-autonomous robotic battlefield systems. Tasking agents will interact with the human commander to formulate a decision hierarchy, nested in a programming protocol, to create the instruction package(s) necessary for robotic system control.

Monitoring agents provide the commander real-time information on organic friendly robotic and manned forces, their disposition, direction, level of capability, and time to completion of assigned instruction packages, as well as progress through directed tasks. The monitoring agent may interface with the tasking agent in situations where human redirection would be recommended, and prompt for a modification of the instruction package.

Coordinating agents will support the transfer of information between a hierarchy of echelons and peer commands to ensure highly integrated missions and flexible execution. Coordinating agents are required for information transfer between the human commanders and controllers, between humans and robotic forces, and between robotic "fighting" platforms and robotic "information" platforms. Lastly, these coordinating agents must contain a capacity for communicating information on extremely fluid fighting environments, where new decisions are made, transmitted, and understood by human and robotic platforms, in a fraction of the time it now takes a typical higher level echelon staff and their organic units.

This three-part approach, tasking, monitoring, and coordinating agents, would efficiently segment the required programming instruction sets, facilitate efficient modification, and enhance survivability. In addition, issues centering on location of tasking, monitoring and coordinating agents should be determined, as well as protocols to reestablish command and control in a different echelon or peer command.

PHASE I: Phase I will design and demonstrate prototype tools and methods that help humans manage robotic systems. Design should target reducing required human interaction with information and robotic systems at the detail level, reducing human training and knowledge required for such interaction, and supporting future C4ISR functions. Design should be based on a review of current and potential FCS robotic management problems, and on state-of-art knowledge and expertise about interface agents. Design should address the need for tasking, monitoring, and coordinating interface agents. Phase I effort should include a market survey of potential commercial partners and customers.

PHASE II: Phase II will develop, assess and refine prototype tools and methods that help humans manage robotic systems. Assessment will include laboratory trials that require users to manage representative problems by applying tasking, monitoring and coordinating interface agents developed during Phase II. Assessment will focus on functionality, usability, training and knowledge requirements for each interface agent. In addition, performance measurement will address: the amount of interaction between humans and systems, management training and knowledge requirements, and commanders' communication and collaboration. Based on this assessment, prototype management tools and methods will be refined.

PHASE III: The prototype management tools and methods developed should provide a powerful basis for helping commanders manage robotic and C4ISR systems in future force organizations. This research should also provide valuable management tools and methods for a wide-range of computer-mediated environments. Interface agents for managing information environments, and orchestrating the performance of subordinate intelligent agents, will be needed in business, industrial, medical and academic settings. Individuals will also require interface agents to help them manage the expanding range of information devices and applications being developed for home and remote environments.

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KEY WORDS: Interface Agents, Robotics, FCS, Information Management, Command and Control.

A01-025 TITLE: Automatic Web-based System for Improving Strategic Leadership Skills

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Development of critical incident scenarios that capture the tacit knowledge underlying senior officer strategic leadership skills. An intelligent software agent based on text knowledge understanding and voice recognition will monitor the semantic content of computer presented scenarios, and engage officers in open-ended discussion, questions, and comments, dealing with current strategic leadership issues. It will have the capability to search current newfeeds and text repositories for documents or parts thereof that it determines to be most relevant to current participant concerns and most likely to provide new information, examples, or ideas that are at the same time understandable to the recipients. Attention to interface and usability issues will be crucial. The agent will also be designed to enhance the Army's status as a learning organization through feedback-based adaptive evaluation and refinement of its use of archived experience.

DESCRIPTION: Current real time text understanding is a promising technology because it can evaluate the content of free-form verbal contributions (potentially in speech as well as typed). It is automatically trained on existing bodies of relevant text rather than through laborious expert-knowledge extraction and hand-coding. Applied research is needed to develop an intelligent software agent for embedding automatic, continuous, and cumulative assessment and tutorial feedback in collaborative learning environments.

This effort will conduct exploratory research to develop an intelligent software agent for embedding automatic, continuous, and cumulative assessment and tutorial feedback based on verbal dialog in distributed collaborative learning environments. The agent will guide collaborative discussion in a Web-based environment for self-development of strategic leadership skills of joint and coalition missions, from Army perspectives. A major requirement of the assessment component is that it measure and provide tutorial feedback on the ability of individuals and groups to autonomously generate, verbally express, and share needed knowledge, create their own problem solution options, and make their own plans, rather than only to choose among alternatives provided on multiple choice tests.

The system will use semantic text analysis or equivalent technology to represent, analyze and characterize scenarios exemplifying best practices in joint, coalition, and international military missions, from Army perspectives. It will use appropriate analyses of important scenarios drawn from the actual experiences of warfighters to induce the underlying relationships among strategic perspectives from Army, Navy and Air Force members on training and operations manuals and procedure and doctrine. It will have a specialized interface to make this knowledge accessible to senior leaders, so they can jointly improve their strategic leadership skills.

PHASE I: The phase I effort will result in a proof-of-concept technology for the objectives and description of this Topic. It will collect a prospective set of strategic leadership scenarios from senior officers. It will demonstrate the feasibility of a semantic text analysis software agent to assist leaders in assessing their own state of strategic knowledge, and improving their strategic leadership skills in socio-political scenarios. Phase I proposals must include a detailed market survey activity and letters of interest/commitment from potential commercial partners must be obtained for Phase II consideration.

PHASE II: Phase II will fully develop, test and validate an intelligent software agent for continuous embedded assessment of open-ended learner verbal productions in a distributed problem-centered collaborative learning environment. It will demonstrate the practicality of further scenario collection to cover the entire scorp of strategic leadership skills. Proposals should assume that the technology will run in the platform-independent web-based infrastructure of ADL. Phase II will fully develop, test and validate a semantic text analysis software agent to assist leaders in assessing their own state of strategic knowledge, and improving their strategic leadership skills in socio-political scenarios

PHASE III: This research has the potential for improving strategic leadership skills in senior Army leaders. In addition, almost every present-day industry or business has a need to train senior personnel in strategic leadership skills such as long term planning, international relations, and socio-political awareness. No flexible automatically constructed assessment and tutorial capability for this training and assessment purpose, such as the one described herein, exists. The development of such a technology will help Government and Private Sector organizations meet the needs of rapidly changing markets, technologies, and labor forces in a timely, effective and economical manner. Further, every large industry with senior leaders engaged in international trade is a potential customer for this technology.

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KEY WORDS: tacit knowledge, leadership skills, leadership training, strategic leadership, intelligent agent, distance learning, senior leadership

A01-026 TITLE: Aptitudes in High Technology, Communication-Intensive Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: This research will develop and validate future-oriented selection, assessment, and assignment tools that measure knowledges, skills, and aptitudes (KSAs) for optimal performance in high technology, communication-intensive environments. The available assessment approaches are sufficient for the existing work environment, but are not designed to address the work demands projected for 2005 to 2025. The future-oriented assessment tools that are the final products of this project will permit selecting, classifying, training, and promoting employees to meet anticipated technology and communication changes the transformation to the Objective Force will bring. The availability of technology must be considered in the development of the assessment tools. The development plan strongly encourages nontraditional approaches to measurement and may include simulations, computer-based measurement, progressive rating systems, knowledge assessment, and experiential measures. For each proposed KSA, an assessment technique must be developed, tested, and validated.

DESCRIPTION: Increased technological capabilities will position the Objective Force to confront missions that place greater demands on individual soldiers and increase responsibility at each level of the Army (Wass de Czege & Biever, 1998). Soldiers, including many young soldiers, will be required to make instantaneous decisions with far reaching and even global implications. Similar demands will be placed on civilians in entry-level positions because they will function as information coordinators rather than system operators (Wickens, 1992). These transformations will change the performance standards, thereby impacting the job requirements and KSAs vital to task completion.

Military experts (Wass de Czege & Biever, 1998) and personnel researchers (Ford, Knapp, Campbell, Campbell, & Walker, 2000) project future soldiers will use many KSAs similar to those used now, but expect the manner in which the KSAs are used and their relative importance will change. KSAs presently treated as inconsequential and seldom, if ever, assessed (e.g., information management, general self-management skill, self-directed learning skill, teamwork, and expressive skills) but may be important to actively classify, manage, and grow soldiers. For example, communication between widely dispersed units always has been important, but the computer skills needed to use new communication and status systems like Force XXI Battle Command Battalion/Brigade and Below (FBCB2) alter both communication and computer skills. Likewise, soldiers always have been required to process information, but current technology has changed the speed and amount of information available. Optimizing performance in this high technology, communication-intensive environment will require new assessment tools and modified procedures to select, assign, and train first-tour soldiers.

Ford et al. (2000) have identified a preliminary list of KSAs anticipated to increase in importance including information management, self-directed learning and general self-management skills, problem-solving/decision making, verbal communication, and integration/coordination for strategic management. Additional research is required to determine the appropriateness and comprehensiveness of this preliminary KSA list. New tools to assess future-oriented KSAs and their changing impact are needed to provide correct selection and assignment of first-tour soldiers because these KSAs have received scant research attention. However, the assessment tools should conform to the constraints necessary to make them useful for large scale testing including minimal costs, effectiveness, and usability.

PHASE I: The phase I effort will provide the proof-of-concept technology for the research objective and description. The products from Phase I will include a delineation of cross-contextual themes (CCT), a compilation of necessary KSAs for success in the future, and an integration of the CCT and KSA research. CCTs are cultural themes anticipated to change or emerge in the future and permeate military and civilian work environments. The investigators should identify KSAs expected to have a greater impact on job success in the future and reflective of general future trends rather than specific jobs. Possible information sources include available scientific material, Army and other military doctrine, and interviews and focus groups with experts such as sociologists, cultural anthropologists, futurists, military personnel in future-oriented units, and scientists and military personnel specializing in selection, classification, and training. Finally, the investigators should explicitly link the CCTs and KSAs. These linkages will highlight those KSAs associated with the cross-contextual themes and therefore most likely to experience the greatest amount of change. These KSAs should be selected for further investigation including critiques of the leading KSA

assessment tools, proposals and critiques of technologically supported alternative measures, and preliminary cost-benefit analyses.

PHASE II: The primary product for Phase II will be empirically validated assessment tools for the future-oriented KSAs. Phase II will capitalize on the CCT and KSA research completed in Phase I. The CCT/KSA Linkages will identify those KSAs likely to have the greatest change and impact on future workplace performance for soldiers and civilians and therefore investigated to a greater degree. Phase II will involve a full-scale development of predictor assessment tool(s) as well as a validation study for the selected KSAs. Using the method critiques, proposals, and cost-benefit analyses, a technologically innovative approach for measuring each KSA will be identified. Prototype assessment tools for each targeted KSA will be developed. Data collection on the prototype assessment tools will be collected in laboratory and field settings. The data will be assessed for reliability. In addition, criterion measures will be collected, developed if necessary, and used to assess the validity of the assessment tools and differential prediction for classification purposes. All of the collected data and practical considerations will be considered and an assessment of the usability of the tool will be provided.

PHASE III: The high technology and communication-intense changes impacting the first-tour soldier are similar to those affecting the civilian entry-level employee. It follows that future soldier KSAs differ very little from the future civilian entry-level KSAs in these environments (cf. Howard, 1995; Wass de Czege & Biever, 2000). Assessment tools are an accepted approach for selection, training, and promotion in civilian and military settings. These tools, however, are often reactive to needs identified by unit leaders in both settings. The assessment tools resulting from this product could help both civilian and military organizations take a proactive stance to prepare their organizations for the 1st quarter of the 21st century.

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KEYWORDS: First tour soldiers, Aptitudes, Selection, KSAs, Future-orientation, Technology

A01-027 TITLE: Virtual Simulation Tools for Cultural Familiarization

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Dismounted BattleSpace BattleLab

OBJECTIVE: To develop and evaluate tools and methods which make virtual simulations a more effective means of training military personnel to work and interact effectively with people of other cultures. This cultural familiarization training should be suitable for use by a unit immediately prior to or after it is deployed on its mission. The emphasis should be on developing specific skills for interacting with members of the culture of interest, rather than developing general skills for interacting with other cultures. It is desired that that this training will take the form of immersive, interactive scenarios which can be tailored to mission requirements. Cultural familiarization will provide the context for mission-specific training on mission procedures, tactics and techniques, and rules of engagement. While being trained, the trainee will interact in a natural way (that is, using voice and gestures) with computer-controlled entities that represent other participants in the training scenario. Key elements of the culture include language, non-verbal communication (gestures, body language, and facial expressions), dress, social and religious practices, living conditions, and social and political history.

DESCRIPTION: During the last decade, the United States Army has been required to conduct an increasing number of missions. Many of these missions represent significant departures from the Army's primary warfighting mission. They include missions conducted to enforce peace agreements, and to provide humanitarian assistance and disaster relief. These missions are often carried out as part of a multi-national force. These missions require leaders and soldiers to possess skills in addition to those required for success in combat. They also often require junior leaders and soldiers to interact and communicate personally and effectively with people whose cultures, languages, lifestyle, and beliefs are very different from those found in the US.

Virtual Environment (VE) technologies have the potential to provide the Army with a training capability to meet these new demands. Immersive virtual simulations have been shown to be effective for training a variety of tactical skills. However, tactical training generally does not require the level of fidelity in representation of interpersonal interaction that is required for cultural familiarization. The technological components necessary for effective cultural familiarization through the use of VE include

knowledge databases, training packages, speech recognizers and synthesizers, automated language tutors, terrain databases, models, human avatars, intelligent tutors, and other aids which can be combined with immersive simulations to familiarize the soldiers with the culture of the region or country in which their deployment or mission will take place.

PHASE I: The vendor shall determine the feasibility of the overall concept by demonstrating a successful linking of several of technologies required for cultural familiarization that the vendor considers to be most critical. These might include immersive VE, voice recognition/synthesis, automated gesture recognition, and automated human entities. The selection of technologies should be based on assessments of the state-of the-art in a variety of areas and an initial system concept that involves the integration of the best available technologies.

PHASE II: During Phase II the vendor develop the overall concept for a complete system. The vendor shall build and evaluate a prototype system based on this concept. Promising individual tools shall be refined and integrated. The prototype need not include a full set of training materials, but nevertheless should include sufficient training to fully exercise and evaluate the system concept and all of the tools. The vendor shall provide a prototype demonstration at the end of Phase II.

PHASE III: The vendor shall build a useable system, to include a complete set of software/training materials for a country or region of interest to the Army. The vendor shall evaluate the full system and training materials using military personnel. Vendor integration and evaluation shall be executed at the DBBL Simulation Center. While the system need not be ruggedized, it should be transportable and suitable for use in a variety of office-like settings.

Other potential customers within the federal government include the Stare Department (training of diplomatic personnel) and the Peace Corps. In the commercial sector, multi-national corporations and corporations that do business overseas should be a market for this technology. Police and emergency service personnel in cities with diverse populations constitute another potential market. Training materials with reduced capability, marketed as software packages suitable for use on desktop PCs with voice recognition and synthesis, could be used in schools and recreational travelers.

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4) For examples of textual cultural familiarization, see the US Army Foreign Military Studies Office Special Editions at http://call.army.mil/call/homepage/special.htm

KEYWORDS: Virtual Environments, Virtual Reality, military training, speech recognition, speech synthesis, gesture recognition, intelligent tutor, immersive simulation, virtual simulation

A01-028 TITLE: Radar Signature Prediction

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: PM-Crusader

OBJECTIVE: Formulate the underlying theory, develop the necessary numerical solution approach and establish the necessary High Performance Computing (HPC) algorithms that will significantly advance the state-of-the-art in the prediction of accurate radar cross section (RCS) data and corresponding inverse synthetic aperture radar (ISAR) images for complex ground vehicle targets. Particular interest is focused in the frequency range of 50 to 200 GHz (millimeter wave), however, there is substantial interest at the lower frequencies and in ultra wide-band approaches.

DESCRIPTION: For large structures, standard EM (electromagnetic) modeling algorithms quickly overwhelm existing supercomputer resources. The level of detail in target models must significantly increase since features on the order of a few wavelengths are expected to contribute to the target signature. Existing sources have translated into threats throughout the spectrum extending up to W-band. EM analysis under the higher frequency conditions often rely on ray tracing techniques which encompass various asymptotic analytical approaches such as geometrical optics (GO), physical optics (PO), geometrical theory of diffraction (GTD), etc. Development in the time or frequency domain is acceptable. The proposed approach must account for

the presence of the earth ground beneath the target when it is relevant to the data. Other considerations can include foliage penetration and other electromagnetic obscurants (natural or man-made). Mathematical techniques such as differential geometry, or Clifford algebraic structures may prove useful in ray tracing performance. Clever techniques involving numerical processing (employing packed integer representations, wavelet or compression techniques, for example) might be exploited. Target modeling using high order basis representations may be helpful. Statistical approaches to attack complex target detail could prove advantageous. Combinations of the above approaches that include basic low frequency algorithms to produce a hybrid analysis tool are only beginning to be investigated by the DoD. Note: DoD HPC resources will be made available to the winning contractors at no cost.

PHASE I: This portion of the effort will focus on defining the underlying physics and numerical approach and then implementing the concept in appropriate numerical algorithms appropriate for HPC environments to the point of demonstrating feasibility. A numerical demonstration with a canonical body is acceptable. Documentation explaining the algorithms and any known limitations is required.

PHASE II: Take the Phase I results to the level of a usable stand alone DoD computational tool suitable for applications on the high performance supercomputers to include parallelization and bench mark testing. Conduct additional comparison studies and examine the range of validity for the approach. Develop and implement the user interface. Supply complete documentation on the capabilities of the method and its implementation.

PHASE III: Radar applications in commercial aviation, transportation and the security industry. Another area of application may be in the medical imaging technology.

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Bhattacharyya, A., (1995) High Frequency Electromagnetic Techniques, Recent Advances and Applications, John Wiley & Sons, Inc.

KEYWORDS: Signature modeling and simulation, RCS, Numerical algorithms, radar, imaging, electromagnetic scattering, target recognition

A01-029 TITLE: A New Reverse Osmosis Membrane for Water Purification

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Petroleum and Water Systems

OBJECTIVE: The goal is to prepare a new polyamide membrane that is chlorine and biofouling resistant for use by DoD and industry in reverse osmosis water purification units. This will save DoD millions of dollars due to significantly reducing logistics, maintenance time, and membrane cost due to reducing the need for water pre- and post-treatment and frequent replacement of degraded and fouled membranes.

DESCRIPTION: Mobile reverse osmosis water purification units have been used by DoD since 1977 to produce potable water for field applications. Although technological advances have greatly enhanced the operation and performance of the spiral membrane elements, several deficiencies still exist, of which the most critical are poor chemical stability to oxidants, such as chlorine, and high fouling rates (refs. 1 and 2). Because of these deficiencies, large quantities of membranes have to be transported to the field and frequently replaced, thus the logistics and maintenance time associated with purchasing, transporting, and replacing membranes is substantial. In addition because commercial membranes are not chlorine and biofouling resistant, costly pre- and post-water treatment is required during the reverse osmosis water purification process to extend membrane lifetimes.

ARO-funded research recently discovered a new polyamide membrane that has improved flow rates and is resistant to chlorine degradation and biofouling. Researchers prepared the all trans stereoisomer of cyclopentanetetracarboxylic acid chloride and used it in the preparation of a model polyamide thin-film composite membrane using an interfacial reaction of m-phenylenediamine with trimesoyl acid chloride. This approach was based on the work of Ikeda et al. (ref. 3). Membrane swatches were evaluated along side commercial membranes at several government water treatment facilities and were found to be considerably more chlorine and biofouling resistant and have a greater flow rate compared to the commercial membranes. While the proof of concept is promising, considerable research and development is needed before commercialization can be realized. This SBIR topic focuses on scaling up the synthesis and understanding bonding and delamination of the membranes to the polysulfone support, which is a critical parameter in preparing membranes that are robust. Exploration of reactant compositions and their effect on the porous nature of the membrane are needed. It is believed that the porous structure leads to

mechanical failure under some test conditions. Finally membrane treatments are of interest for enhancing hydrophilicity to further enhance biofouling resistance.

PHASE I: The goal is to prepare 50 grams of the all trans stereoisomer of cyclopentanetetracarboxylic acid chloride (99.9% pure) and use it to prepare polyamide thin-film composite membranes using an interfacial reaction of m-phenylenediamine with trimesoyl acid chloride. Model membranes (swatches) will be prepared from this and key issues, such as the cause and cure for delamination of the membrane from its support, will be explored as a function of membrane composition and processing conditions. Adsorption enhancers will be explored to eliminate delamination. These could be used in the support, the m-phenylenediamine phase, or both. Factors that control the porous structure of the membranes will be explored in order to eliminate mechanical failure. This will be investigated by modifying the physical structure of the membranes by varying the compositions of both the m-phenylenediamine and the acid chloride reactant solutions during interfacial membrane formation.

PHASE II: Phase II will refine the synthetic process to demonstrate it can meet industry needs for scale-up and will focus on optimizing membrane composition and properties, such as, flow rate, chlorine resistance, biofouling resistance, and mechanical robustness, based on the results of Phase I. The PI will partner with industry to prepare spiral wound membrane elements using the industry standard process. Long-term membrane evaluation in actual elements will be done at water purification facilities (to be facilitated by topic author) using a variety of water compositions, such as seawater and brackish water. Swatch tests will be used concurrently for rapid evaluation of function and properties during optimization and long-term evaluation at water purification facilities.

PHASE III: The new polyamide reverse osmosis membrane will significantly lower water purification costs incurred by users by increasing system efficiency while requiring less frequent membrane replacement. Large-scale units are used throughout the world, including at water purification facilities for local governments in the U.S. With an active and growing commercial market already established for water purification systems, the advances proposed here would be of great value to both vendors and users. The membranes will be developed using environmentally benign materials and processing thus eliminating any negative environmental impact. These new membranes can be manufactured without any changes to current industrial production due to their similarity to current commercial membranes.

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2) "Biofouling of Reverse Osmosis Membranes" in Biofouling and Biocorrosion in Industrial Water Systems, H. Ridgway and J. Safarik, J. Mallevialle, P. Odendaal, and M. Weisner Eds., McGraw-Hill Publishers, New York, p. 81, 1996.
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KEY WORDS: reverse osmosis, polyamide membrane, spiral wound element, chlorine degradation, biofouling membrane, water purification

A01-030 TITLE: Selectively Permeable Elastomeric Membranes for Protective Clothing

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PM Soldier Equipment - Fort Belvoir

OBJECTIVE: Develop and fabricate economical and lightweight chemical protective clothing that demonstrates flexibility, durability, and selectively permeable properties utilizing a relatively thin (1-4 mil), non-laminated elastomeric membrane.

DESCRIPTION: The U. S. Army requires that all fielded systems be survivable in a chemical warfare environment. Butyl rubber is currently used in standard protective clothing because it provides good protection from chemical and biological agents. However, the bulky and impermeable nature of butyl rubber results in unacceptable levels of heat stress on the soldier.1 Outfitting the soldier in accordance with new Future Combat System (FCS) and Objective Force guidelines require that the materials be lightweight and flexible, enabling the soldier to move freely. In an effort to address these multiple requirements, a series of sulfonated tri-block copolymers have been developed.2-4 The novel polymers are comprised of polyisobutylene as a major component to afford inherent barrier properties to the block copolymer. The novel block copolymers exhibit flexibility over a broad temperature range and selectively permeable "membrane-like" characteristics.

PHASE I: Research efforts should focus on the design and synthesis of a copolymer(s)/ionomer(s) comprised in part of polyisobutylene (PIB) that will enable flexibility over a broad temperature range (~-60°C-100°C), that can be economically processed as coated woven fabrics, gloves, tenting, and stacked fuel cells, and that exhibits transport of water vapor while blocking transport of polar organic compounds. Results from the Phase I effort should demonstrate the above characteristics and define a clear and feasible synthetic route that will enable production of the elastomeric membrane at pilot plant level. Economic analysis shall be performed to determine the estimated cost to produce the membrane at pilot plant level. The elastomeric membrane should exhibit durability, flexibility and selective transport properties necessary for use in field operations and chemical warfare environments. That is, the membrane should "breathe", allowing water vapor transport away from the soldier, thereby reducing heat stress, while simultaneously blocking penetration of harmful substances is liquid or vapor form.

PHASE II: With candidate materials identified in Phase I, the Phase II program should address scale-up of the elastomeric membrane. The copolymer shall be used in the fabrication of prototypes to include a coated fabric outer garment and elastomeric chemically protective gloves. Testing of the prototypes will be performed to demonstrate flexibility, durability, breathability, and protection against actual chemical warfare agents. Detailed fabrication procedures for the prototypes shall be established. Economic analysis shall be performed to determine the cost of fabricating a full body protective suit for military applications, utilizing the polymer membrane.

PHASE III: Successful development of the polymeric membrane may have numerous applications as biomedical materials that require selective water transport (i.e. wound dressings) and as alternative fuel cell membranes. Economically feasible chemical protective suits would be useful in numerous "threat-response" applications for law enforcement organizations and for hazardous material clean-up operations.

OPERATING AND SUPPORT COST REDUCTION (OSCR): O & S cost reduction will result from the successful development and implementation of this technology by significant reduction in weight and enhanced survivability of the soldier.

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KEY WORDS: copolymer, membrane, ionomer, protective clothing, water transport, barrier, elastomer

A01-031 TITLE: Test Fixture for Ascertaining Blunt Trauma

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Project Manager-Soldier, Fort Belvoir, VA

OBJECTIVE: Design and development of an instrumented test fixture to measure the response of the human thorax to non-penetrating ballistic impact. This fixture will enable the assessment of non-lethal weapons effectiveness, and the potential for blunt force trauma injuries associated with personal body armor back-face deformation when used as protection against otherwise lethal threats. The mechanical surrogate of the human thorax should measure the time- and space-resolved loading and deformation of a human thorax, including rate effects, associated with the energy and momentum transfer due to non-penetrating impact by military anti-personnel (lethal and non-lethal), and small caliber armor piercing ammunition. Data obtained using this fixture will be used to assess and model blunt force trauma, incapacitation and survivability criteria for personnel.

DESCRIPTION: Researchers and developers of personal body armor systems have a need for reliable experimental techniques for assessing the vulnerability of personnel due to impact loading related to stopping small arms projectiles while wearing body armor. Likewise, developers of anti-personnel ammunition, both lethal and non-lethal, require quantitative measures of weapons effectiveness for enemy incapacitation. Impact induced loading occurs through the transfer of energy and momentum from the projectile, through the armor materials, to the human wearer. The initial deformation of the armor materials is caused the propagation of impact induced stress waves and their interactions, and the subsequent deformation of the materials occurs through sustained stress imposed on it after the wave interaction effects are completed. The initial deformation of the material and associated energy and momentum causes changes in the material to take place during the first few microseconds after the impact. This leads to changes in the initial mechanical properties of the material, which may influence the material response to

the sustained stresses. The objective of this effort is to accurately experimentally measure the ballistic momentum and energy imparted to the human thorax, with a goal of understanding how various armor system components and combinations may mitigate the blunt force trauma associated with ballistic impact, and to help identify design parameters for enhanced non-lethal weapons.

PHASE I: Establish the feasibility of a Test Fixture to Ascertain Ballistic Trauma that can be used to measure the loading and deformation of a human thorax from the ballistic threats listed in the description.

PHASE II: Fabricate Test Fixture to Ascertain Ballistic Trauma.

PHASE III: Potential exists for supplementing National Institute of Justice prescribed test fixtures, and use in development of commercial ballistic personal protective systems.

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5) Keywords: Ballistics, Body Armor, Test Fixture, Blunt Trauma

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A01-032 TITLE: Portable Electrochemical DNA Biosensor Unit

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Electrochemical technology allows for rapid (millisecond) direct detection of specific nucleic acids at very low concentrations. This technology can detect attomole amounts of specific DNA in unpurified samples. Research is needed to develop this technology into a small, portable unit that can be used in the field, and to design a unit specific for Army needs.

DESCRIPTION: The use of biological weapons by terrorists or rogue nations is a concern of military and civilian populations. While technological advances have been made in the detection of biological weapons, incorporation of new technology into detection devices is necessary to increase the robustness of pathogen detection, to counter the potential for increasingly sophisticated manipulations of biomaterials, and to eliminate false positives. DNA-based detection systems have the potential to unambiguously identify pathogens, however these types of systems have been hampered in the past by the amount of time required for polymerase chain reaction (PCR). The development of electrochemical DNA detection technology eliminates the need for time-consuming PCR. Avoiding PCR enables detection in milliseconds instead of hours, and eliminates distortions caused by differential amplification efficiencies. In addition this technology allows the elimination of radioactive or fluorescent reagents (that previously needed to be replenished), and eliminates the need for an optical system. Eliminating the optical system reduces the size requirements of this device. Obviating the need for radioactive or fluorescent labels also allows dozens of probes to be hybridized to each sample in each microwell. Multiple probes are necessary to eliminate false positives, and to avoid lack of detection due to genetic engineering of pathogens. Electrochemical DNA detection technology will enable the Army to detect pathogens in real time, reducing exposure to pathogens and infectious diseases from both natural and unnatural sources.

PHASE I: In Phase I, it will be necessary to demonstrate the ability to detect low concentrations of specific pathogens in unpurified samples. Using multiple probes for each pathogen, demonstrate an robust identification rate and no false positives. Design and demonstrate a plan for building a portable pathogen sensor unit based on these results. Successful completion of Phase I will be the demonstration of effective pathogen detection with no false positives, and the design of devices to incorporate this technology into small, hand-held, portable sensor units.

PHASE II: Develop electrochemical detection technology into a small, portable unit that can be used in the field. The ideal product will be lightweight, withstand shock and temperature extremes, and operate with little or no user training. Sample intake and processing will be automatic and continuous in order to have real time detection of bacteria, viruses, and other pathogens. The unit will conduct reactions in nanoliter size volumes in order to be able to process a large number of samples without requiring human input or more reagents. Probes will be designed to detect infectious disease pathogens of significance to the Army, as well as other potential biological threat agents. Multiple probes for each pathogen will be utilized to eliminate false positives. Major advancements in electrochemical DNA detection technology, such as combining active hybridization with electrochemical detection, will be demonstrated. The unit will be tested under field conditions and demonstrated to be capable of detecting military relevant pathogens (such as anthrax) at low concentrations.

PHASE III: The use of devices that could be made using this technology is enormous. Any situation where transmission of infectious agents from one human to another, or any situation where uptake of natural or unnatural pathogens from food, water, or the environment is a concern, is a place where use of such a product could reduce illness and/or death. Obvious locations where such a device would be wanted are schools, nursing homes, hospitals, cafeterias, and food-processing industries. In addition, these devices could be used for: biochips for genomic research, microtiter plates for drug discovery, and hand-held devices for bioprocess controls, or for point of care medical diagnostics.

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KEYWORDS: Biosensors, electrochemical detection, pathogens.

A01-033 TITLE: Airless Wheel for Future Tactical and Combat Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: National Automotive Center (NAC)

DESCRIPTION: The Army's Objective Force will make extensive use of wheeled vehicles in both tactical and combat roles. Future vehicles must traverse soft and complex terrain that heretofore was the exclusive domain of tracked vehicles. Continuous operational speeds greater than 50 mph across rough terrain with highway dash speeds reaching 100 mph are required. The Army's required operational tempo does not tolerate delays due to flat tires or minor damage from small arms. Differential wheel speed steering will be used to augment steering and requires tailoring wheel-tire stiffness to achieve optimal steering performance. While the latest pneumatic run flat technology being developed by the automotive tire industry may be sufficient for on-road commercial use, this technology is woefully inadequate to meet the continuous operational needs of the Army's Objective Force.

OBJECTIVE: It is the objective of this effort to encourage innovative, high technical risk airless tire-wheel concepts that meet the aforementioned operational conditions. The offeror should use a commercial 31X10.50R15LT Goodyear Wrangler AT/S radial tire and conventional steel wheel on a representative 4000 lb. differential wheel speed steered sport utility vehicle for sizing their airless tire-wheel concept. The concept should be lighter in weight than conventional run flat tire-wheel combinations and should be small arms damage tolerant. The proposed tire-wheel concept can be a single or multiple piece design, however, simplicity of design is preferred. The offeror is not constrained to using rubber as the structural material, however rubber for the tread may still be appropriate. The tread geometry and operational characteristics should be adaptable, that is passively and or actively tailorable, to support optimum surface adherence and maximum mobility over any terrain and surface condition. The tire-wheel concept should lend itself to automated manufacturing processes. The offeror can integrate any technology that promotes soft and complex terrain mobility provided the soldier does not need to stop the vehicle to install or make manual adjustments to the system. The airless tire-wheel concept should be operationally friendly in urban, highway and

off road settings under all environmental conditions. It can be assumed that electrical power can be transmitted to the wheel, however power consumption should be minimized.

PHASE I: Develop an innovative airless tire concept and demonstrate feasibility through analyses and scaled testing.

PHASE II: Demonstrate concept on full-scale prototype over various terrain profiles.

PHASE III: Commercial application for airless tire/wheel concepts is obviously synergistic with the Army's Future Combat Systems. Certainly on- or off-road commercial vehicles will benefit from this technology, particularly SUV types on slippery surfaces or rough terrain. The automotive industry has been developing some non-pneumatic concepts for safe, run flat tires for everyday commercial use. The technology may also be used in farming and agricultural industries, and space applications include mars rover vehicle.

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KEYWORDS: Airless Tires, Non-pneumatic tires, Run flat, Differential steer, Mobility

A01-034 TITLE: Research in Intrusion Detection Systems for Attacks Occuring in High-Speed Data Streams

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DoD High Performance Computing Modernization Prgm

OBJECTIVE: The objective is to conduct research into Intrusion Detection Systems to detect, analyze, and contain attacks occurring in high-speed (OC-12 and above) data streams.

DESCRIPTION: As military information systems and computer mediated communication technologies become essential force multipliers, their reliability, availability, and integrity becomes a critical readiness element. Improved technologies and techniques are needed to support both the breadth (extension of networking to the foxhole and remote sensor) and depth (higher speed communications in the rear echelons and for RDT&E) of objective force networking. Methods and concepts that can automate self- and peer-checking; that are sensitive to broader categories of tampering and attack; and that make military information systems more resistant to attack are needed. Improved reasoning and/or knowledge extraction systems that can operate in a noisy, low energy budget environment; and that can detect and respond to new attack scenarios without human intervention or prior configuration are of particular interest, as are distributed and parallel implementations that can partition the workload to enhance the detection and analysis process.

PHASE I: Investigate current pattern-space mapping techniques to identify promising feature or anomaly detection methods that can rapidly extract and classify small signals from massive quantities of data.

PHASE II: Select one or two of the candidates identified in Phase I for prototype implementation to develop a practical understanding of their strengths and weaknesses.

PHASE III: Using the information and experience developed in Phases I and II, refine and extend the research criteria so the program leads to deployable products. Successful products will be incorporated into militarily significant information systems at all levels (foxhole to rear echelon) to detect and mitigate hostile activities directed against these systems. In aggregation, these sensors can be used to develop a "network weather" forecast that can be used for information assurance activities (to protect friendly assets) and information operations activities (to target active enemy assets). In the commercial sector, extremely small-footprint tools and techniques that can detect and defend against hostile activity in the tactical environment are likely to find application in the embedded systems that are becoming more pervasive throughout society. It will be important to protect devices that are network accessible for convenience, but that must be resistant to the random whims of unauthorized interlopers (e.g. a homeowner would derive significant peace of mind from being able to check the status of his home heating/cooling system while on vacation, but would not want just anybody to be able to turn off the furnace in his Minnesota home in January). Tools and techniques which have sufficient power to process the tremendous data-flows (both in terms of aggregate throughput and individual connection bandwidths) associated with rear echelon communication centers and high performance computing centers will also be of interest to the major Internet backbone and Internet Service Providers. The ability to provide service guarantees and security assurances to business customers is becoming a critical factor to the success of these companies, and the tools and techniques developed for the military will have a direct application in support of large (and explosively growing) commercial Internet markets.

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KEYWORDS: Security, detection, anomalous behavior, computer attacks, hacking, hackers, data mining, artificial intelligence, data integrity, authentication

A01-035 TITLE: Shear Thickening Fabrics for Lightweight Flexible Protection

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop lightweight flexible fabrics based on shear thickening fluids and high performance fibers in order to provide simultaneous protection against abrasion, snag, cut, puncture, and blunt trauma.

DESCRIPTION: Research in the area of shear thickening fluids has demonstrated greater than 100-fold viscosity increases that are both discontinuous and reversible in concentrated suspensions of solid particles. Although investigations have historically focused on minimizing or eliminating this phenomenon in industrial processes, shear thickening fabrics offer excellent and unique potential as flexible protective materials, and only recently have the origins of the phenomena been analyzed and simulated in simple systems [1]. Recent developments in processing, most notably electrospinning, melt spinning, and fluid impregnation processes (including the development of cellular polymer matrix composites), have made possible the encapsulation of shear thickening fluids (which may themselves be pre-enclosed in flexible membranes for ease of processing) within a matrix of high performance fibers in order to create extraordinary flexible fabrics. The extent of the shear thickening, required shear rate, and onset time have been demonstrated to be materials-dependant parameters which are heavily dependent upon phase volume, particle distribution, and particle shape [2]. It is expected that a shear thickening fluid could be optimally designed and incorporated into a high performance fiber matrix in order to provide a lightweight flexible material system offering excellent protection against a large number of the most common threats. Specifically, abrasion resistance, snag resistance, and blunt trauma protection would be enabled by the shear thickening response, while cut and snag protection would be facilitated by the high performance fiber matrix. Such materials would be immediately applicable to the Army's need for increased soldier protection, particularly in terms of gloves and other extremity protection. Shear thickening fabrics have potential to provide simultaneous protection against an array of the most common threats facing the solider; such protection is simply unattainable with conventional material and fabric solutions. Specific research requirements include: (1) development and experimental verification of materials design tools capable of predicting the extent of shear thickening, required rate of shear, onset time, flexibility, density, variation with temperature, and suspension stability based on specific design parameters (including composition, phase volume, and particle shape and size), (2) determination of an optimized design strategy for integrating shear thickening fluids into high performance fiber matrices, and (3) development of the synthesis and processing technology necessary to inexpensively fabricate optimized shear thickening fabrics.

PHASE I: Demonstrate the fabrication of a representative sample of shear thickening fabric in order to evaluate the potential for the production of a complex component for DoD and commercial applications. The critical processing steps should be identified and the preliminary materials design tools and materials selection strategies established. Sample fabric characterization and testing are required (both experimental and computational), and must include biaxial stress and strain, puncture, and abrasion resistance testing.

PHASE II: Develop robust materials design tools for shear thickening fabrics and conduct statistically significant characterization testing on the optimum shear thickening fabric to quantify abrasion, cut, puncture, snag, and blunt trauma protection. Further demonstrate the technological advances achieved in flexibility and protective capabilities via the production of a prototype glove with optimized fabric design.

PHASE III: Fabricate optimized protective fabrics into gloves and other articles of clothing in order to improve flexibility and protective capabilities. Optimize the process and component design for fabrication on a plant scale. These materials are

expected to provide enhanced flexibility and protective capabilities for many types of clothing, apparel, and protective equipment (including military, medical, and sports applications).

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KEY WORDS: Shear thickening, high performance fibers, fabrics, protection, flexibility

A01-036 TITLE: Automated Dummy for Crewstation Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Design and build a prototype automated dummy to serve as a surrogate for humans in crew station evaluations and technical tests. An automated dummy is not currently available for research and development in crew station design. Leverage ongoing work in anthropometry and address multiple external stimuli as normally experienced by a human as well as define physical limitations that would be imposed on a human in a crewstation. Create new built-in analytical tools to model and present data collected on exposure to ambient energy such as shock, vibration, light, sound, and temperature. Provide capability to assess crew space reach and vision limits across the range of user population in such as way as to provide new metrics of human limitations.

DESCRIPTION: Current dummies come in fixed sizes, are representative of a very small percentage of the user population, do not address crew space accommodation, and are geared toward extremely hazardous environments. As the human engineering community moves away from univariate to multivariate techniques for assessing crewstation adequacy and emphasis on long-term exposures, new dummies will be needed that differ considerably from the current designs. Evaluations with humans require extensive coordination at considerable cost to obtain sufficient people representative of the sizes and shapes of potential crewmembers. The U. S. Air Force conducted such studies to characterize current crewstations to identify who fits properly, to establish size criteria. A dummy would have simplified this study. Human figure modeling can analyze some but not all of the possible combinations of clothing and personnel and would benefit from the data a dummy can provide. Consequently, while we are pursuing enhancements to the design process through our Crew Station Design Tool effort and the U. S. Air Force and Navy are improving design tools as well, there is still a need for data with real systems. The technologies presently used (sensors geared to short intense bursts of energy as opposed to 8-hour measurement of exposure for example) are not conducive to the new approach. The purpose of this SBIR is to provide the research necessary to overcome the technical barriers to new dummy design. Consequently, it will be necessary to identify techniques to create new dummies which are quickly reconfigured to a wide range of sizes, use automation algorithms to manage movement routines of the dummy's arms, legs, and head, provide new types of instrumentation, and can withstand the long-term data collection events. One of the potential benefits of this approach is the capability to collect multiple types of energy measurements at the same time in a much more realistic manner than at present. We could then explore the potential development of new definitions of hazardous energy levels either on a single basis (such as heat absorption rather than temperature) or across measures (such as a combination vibration plus heat index). The first problem this SBIR addresses is that within the Army and Air Force, current human engineering approaches are moving away from a focus on single dimension percentiles (5th percentile female to 95th percentile male stature for example) to an emphasis on techniques for addressing a desired percentage of the population in crewstation accommodation evaluations. CAESAR and work at Natick on boundary manikins are examples. The second problem that a new dummy would help us address is the capability for measuring energy levels of concern (such as vibration, shock, temperature, and noise) to humans in longer-term operations in new ways. The objective is to create an automated dummy that can substitute for a human to assess crew station design and provide data to further enhance human models in the computer-aided-design environment. The long-term goal is for the automated dummy to become a standard data collection device and measurement integration tool for long-duration operations in much the same manner as crash dummies are for evaluation of crash incidences. In addition, this dummy could standardize crewstation analysis approaches for Joint Service programs.

PHASE I: Conduct a feasibility study of a concept design. Examine existing dummies and instrumentation and identify types of data that are feasible for the automated dummy to collect as well as the potential areas for improving the quality of soldier performance data collection. Identify major areas of research and technical innovations required to overcome the technical barriers of adjustable-sizing, precision motor controllers, and automation algorithms in the creation of the dummy in Phase II. Complete plan for Phase II.

PHASE II: At a minimum, create prototype designs for a small female and large male based upon U. S. Army anthropometric database and emerging CAESAR data including considerations for incorporating multivariate boundary manikin capabilities. Demonstrate the ability for the dummy to adapt to multiple sets of anthropometric dimensions, provide innovative new

integration indices, and capability to be used with current clothing ensembles. Identify potential problems with calibration and maintenance of the dummy as well as mechanisms for referencing the dummy to the crewstation and reporting analyses of the data.

PHASE III: The primary goal for Phase III is to demonstrate the dummy's capability to evaluate a current vehicle (a car of the contractor's choosing) and the crew station of an Army vehicle (to be chosen by ARL-HRED). Complete development of dummies and perform validation studies of concepts. Researchers for years have used crash dummies to augment development of models of human interaction with protection systems; we expect the automated dummy to be used in a similar manner. The commercial sector conducts far more testing of vehicles and simulators and of a wider variety than the Army. In many cases it is simply not possible to collect extensive sets of data to support decisions concerning passenger or crewmember accommodation. In addition, the availability of these dummies will help standardize data collection processes across international boundaries. Once prototypes are created, interest in the commercial sector will drive development and refinement of the dummies as has occurred in the crash dummy sector over the past 50 years across many organizations. The automated dummy will expand the current base of commercial capability.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The Army will benefit from reduction in time required for people in testing and from the standardization in data collection. Both benefits will help program managers, such as Future Combat Systems, Future Scout Cavalry System, Comanche or concept programs such as Future Heavy Tactical Truck, to understand how their systems will be evaluated. Once use of the dummies is standardized, quantifiable performance specifications can be written around the capabilities of the dummies in a similar manner as current crash dummies. This standardization will dramatically simplify evaluations across joint service and international systems, since all can be compared to a commonly understood criteria. Consequently, when the Army evaluates foreign systems, the criteria of performance will be a standard set of dummy profiles readily available and understandable by worldwide vehicle manufacturers. Implementation of this SBIR now will ensure the availability of the automated dummy when FCS is ready for evaluation.

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KEYWORDS: Human Engineering, Ergonomics, Dummies, Crew Station Design, Anthropomorphic Manikins

A01-037 TITLE: Modeling Integrated Helmets for Aviation

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Program Manager for Aircrew Integrated Systems

OBJECTIVE: Create a finite-element model of the interaction between an aviator's helmet with all of its associated ancillary equipment and the aviator's head.

DESCRIPTION: Future aviation weapons systems will require new innovative designs of helmets in order to incorporate advanced technology capabilities. The helmet must provide protection from a wide variety of future hazards and provide a platform for advanced sensors. The goal of the SBIR is to create a finite-element based model of the relationship between the sizing and fit of a helmet on comfort, the pressure exerted by the helmet on the head, and the protection provided by the helmet in the cockpit environment. In addition, the model should provide the capability to assess compatibility of helmet components with its associated ancillary equipment and any aircraft interface systems. The model should be developed with the capability for future integration with other head-related models such as center of gravity effect upon neck injury during crash impact, that assess blunt trauma, noise reduction, and projectile penetration. The model should provide the capability to evaluate the full spectrum of head size variations from 2nd percentile female to 98th percentile male. The model should quickly and automatically evaluate fit and comfort through a simple graphical user interface.

PHASE I: Identify types of data that are required for model development and determine technical innovations required to overcome the technical barriers in the creation of the model in Phase II. Identify relevant measures of protection and means for modeling them. Identify a complete list of associated components required to create a complete database and identify means for creating computerized database of components. Complete plan for Phase II.

PHASE II: At a minimum, create a fully functional model and demonstrate and validate for database of at least 100 3-dimensional computer-based heads using data from the U. S. Army Anthropometric Database or existing 3 dimensional databases including considerations for incorporating boundary figure capabilities. Develop model around one current aviation helmet (HGU-56/P) with associated equipment, demonstrate the model's capability to provide the required capabilities, and use the model on a new system of the contractor's choice to validate the model.

PHASE III: Helmets are used for a wide variety of applications (sports, motorcycles, aircraft) in the commercial and military sectors. The technology created under this SBIR will transfer readily to the commercial sector. This SBIR also provides the basic building block for incorporating other models related to design of equipment for use with the head such as blunt trauma, airflow, and noise reduction.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Cost reductions will come from decreases in turnaround times for creating and evaluating feasible concepts of new helmet systems. Present processes are slow and require multiple iterations of design and evaluation to correct design limitations and problems.

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KEYWORDS: Human Engineering, Ergonomics, Finite Element Analysis, Modeling and Simulation, Integrated Helmet

A01-038 TITLE: Polymerase Chain Reaction-less DNA Detection System

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop a polymerase chain reaction (PCR)-free DNA detection system for high sensitivity identification of BW threat agents and infectious diseases.

DESCRIPTION: The detection of biological warfare agents is a significant challenge to the scientific community. Recent advances in the areas of nanotechnology and DNA detection have made highly sensitive and selective identification of threat agents an achievable goal. A remaining challenge is to increase the sensitivity of these techniques to the point where DNA amplification and replication is not a requirement for the method. Meeting this challenge will result in technologies with lower support requirements and faster detection and identification of threat agent. Recent advances in signal amplification using nanoparticle-based systems provide one potential method for achieving sufficient signal amplification to overcome the requirement for PCR amplification. The technology can then be adapted for use in the medical community for use in infectious disease diagnosis. Since many of the agents that are considered biological threats are infectious disease agents or modifications of disease-causing species, the system would need to have the complementary DNA fragment for the target agent in its recognition component. A system having either multiple agent capability or easily switchable recognition elements would be well suited to this use. Since the only necessary change is in the recognition elements and the remainder of the system would be unchanged, demonstration of the technology for a high priority target such as anthrax would indicate the success of the device. The final system needs to be i) highly sensitive (<10 fmole of DNA); ii) highly selective (single base pair mismatch); iii) resistant to interference by materials present in biological samples, aerosol samples, or water samples; iv) resistant to interference or contamination by non-target DNA or DNA fragments; and v) low in power requirements and small in size.

PHASE I: In Phase I, it will be necessary to demonstrate a technique which is capable of highly specific DNA detection in the low (<10) fmole range. Use of nanoparticle signal amplification is one potential means of achieving high sensitivity. The technique must demonstrate resistance to non-cooperative DNA binding while maintaining extremely low rates of misidentification or false alarm. In this phase the use of PCR amplification is acceptable. However, successful completion of this phase will be contingent upon presenting a plan to achieve PCR-less, DNA-based detection of anthrax.

PHASE II: In Phase II, a PCR-less, DNA-based system for the detection of anthrax must be demonstrated. This system should be small, easily portable, have low power requirements, high sensitivity (<10 fmoles of DNA), and high selectivity (single base pair mismatch detection). Use of nanoparticle signal amplification is one potential means of achieving high sensitivity. As with Phase I, resistance to non-cooperative DNA binding, and extremely low rates of misidentification or false alarm, are essential. A completed prototype system will be delivered to the Army (U.S. Army Research Laboratory or Edgewood Chemical/Biological Center) at the completion of this phase.

PHASE III: The commercial applications of a PCR-less, highly sensitive identification system for BW agents and infectious diseases have an enormous potential. The medical diagnostics market and the infrastructure protection arena require devices for rapid, accurate, sensitive detection and identification of biological agents and infectious diseases. In addition, food processing and handling facilities would benefit from systems capable of detection and identification of food poisoning organisms in their working environments to prevent distribution of contaminated products.

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KEYWORDS: DNA detection, biological sensing

A01-039 TITLE: Encapsulation of Armor Ceramics by Affordable Casting Techniques

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO, GROUND COMBAT AND SUPPORT SYSTEMS

Objective: Develop a low cost armor ceramic encapsulation casting technique which utilizes discontinuously reinforced aluminum alloy metal matrix composite (DRA MMC) as the light weight encapsulant material. In addition to being readily affordable, the casting process should be capable of significant scale up from small (6"x 6"x 2.1") target blocks to a minimum of (2 ft x 3 ft x 8 in.) size component and allowing for nonplanar and curved geometries.

Description: Encapsulation of armor ceramics in a weld fabricated and hot isosatatic pressed, HIP, encasement of wrought titanium alloy has been shown by Bruchey and Horwath at the Army Research Laboratory [Ref. 1] to be capable of achieving improved ballistic protection. This approach is relatively expensive and has inherent technical and cost challenges with size scale up and nonplanar and curved geometries. Moreover, a lower density encapsulating material such as an aluminum alloy with >50% volume fraction of discontinuous ceramic particulate reinforcement would offer considerably greater stiffness and reduced weight for a comparable size structure than with the monolithic Ti-6Al-4V alloy material. A casting process appears attractive to minimize the fabrication costs and maximize the future design flexibility and scale up potential for armor applications. Various processes involving the casting of DRA MMC are presently commercially available. Wells et al. [Ref.2] have reported on the use of x-ray Computed Tomography (CT) scans to identify as-fabricated defects in initial and unsuccessful DRA MMC samples made via a pressure infiltration casting process.

PHASE I: Demonstrate the capability of casting target samples with a single monolithic ceramic tile of SiC encapsulated with a highly reinforced DRA MMC material. Demonstrate the feasibility of producing cast encapsulated ceramic targets that are free of significant hot cracking in either the MMC or the ceramic material, excessive porosity and large inclusions and minimal ceramic tile displacement. Secondarily, demonstrate the process control capability of achieving a shear resistant bond between the ceramic tiles with the MMC encapsulating material. Fabricated samples capable of being x-ray CT scanned prior to and following ballistic evaluation at ARL.

PHASE II: Optimize the processing steps to improve quality and accommodate scale up of increased size and configurationally complexity of internal armor ceramic elements. Major costs and encapsulation process control and quality issues associated with the casting process in the context of commercial viability should be explored and documented. Demonstrate the feasibility of cast encapsulation of multiple tiles in a simultaneous casting process which simulates a notional Army ground vehicle component.

PHASE III: In addition to military applications, this technology has potential for commercial applications wherein the use of ceramic inserts allows for selective reinforcement of large structural components with improved affordability.

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KEYWORDS: encapsulation, armor ceramics, metal matrix composites, DRA MMC, casting

A01-040 TITLE: Document Image Enhancement

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, CI/HUMINT Management System (CHIMS)

OBJECTIVE: Develop techniques for processing and enhancement or "clean-up" of bitonal and/or grayscale document images, with the goal of increasing both OCR accuracy and intelligibility for human readers. Using a realistic corpus of document images varying in origin, age, quality, and problem type(s), define, develop, and test methods of document image problem analysis and enhancement, measuring their effect on both OCR accuracy and readability.

DESCRIPTION: The usefulness of document images is often limited by problems such as skew, speckle, low contrast, curved baselines and other character distortions (due to warped paper, photocopying from large books, etc.).

These problems can be interrelated and can influence OCR accuracy, e.g. segments of broken characters can be interpreted as speckle and treated inappropriately by an OCR program, or non-text objects can be interpreted as text regions made up of broken or touching characters, yielding gibberish as OCR output. Character shapes themselves often contribute to confusion, e.g. "rn" being read as "m" [1]. Commercial OCR engines attempt to increase accuracy with a variety of methods, including training on a sample of documents and dictionary lookup.

Readability, the ease with which people can read text, is affected by a number of factors including blur [2], relative contrast levels of text and background [3], and type of background noise [4,5].

Research will focus on improving both OCR accuracy and readability, using new and existing techniques for detection and repair of the problems listed above. Emphasis will be on integrating repair of skew, speckle, etc. [6] with automatic methods of detecting graphics, marginalia, stamps, and other non-text material that can interfere with document image enhancement and OCR [7,8,9]. Development and testing should be based on adequate test databases of document images for which OCR ground truth is available and which show the full range of document image problems described above. Ideally, testing will include a variety of fonts in both Latin (e.g. English) and non-Latin (e.g. Cyrillic) character sets.

Techniques should be evaluated for their effects on both OCR accuracy and readability. OCR accuracy will be measured by character-level precision and recall. Readability should be assessed using accepted tests such as letter identification [4], word or phrase spotting [5], speed [10], proofreading accuracy [10], or comprehension [11].

PHASE I: Develop a feasibility design for new tools and methods for document image enhancement, and test design for both OCR accuracy (precision and recall at the character and word levels) and readability.

PHASE II: The design developed in PHASE I should be prototyped and demonstrated on a realistic test database of documents images. In addition, specialization of the prototyped tools should be demonstrated to test data in both military and commercial domains.

PHASE III: Dual use applications include OCR for keyword extraction and topic recognition on documents obtained in field operations, and similar use in litigation support, financial services
document management, medical records, and construction of document archives in business, universities, and government.

COMMERCIAL POTENTIAL: Techniques from this effort are potentially marketable as products to increase accuracy of OCR and readability for document images in financial services, medical records, litigation support, and record archiving for corporations, universities, and government.

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KEYWORDS: Document management, document image enhancement, OCR, document readability.

A01-041 TITLE: Processing of Nitrided Magnetic Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The goal of the research is to identify processing approaches that are amenable to the production of several promising new nitrogen-based magnetic systems.

DESCRIPTION: In the early 1990's several nitrogen-based compounds were identified that displayed outstanding magnetic properties. Unfortunately, processing limitations thwarted commercialization. In particular, Sm2Fe17Nx was identified as a hard magnet with potential for providing exceptional energy product values above 300 degrees C.(1,2) Unfortunately, it is unstable at elevated temperatures making standard high-temperature compaction and annealing methods impossible. Likewise, alpha-Fe16N2 was found to offer record saturation magnetizations (estimated to be around 300 emu/gm), but involves a peritectic reaction to a metastable phase. To date, only mixtures containing a minority concentration of the alpha phase have been formed, e.g. by quenching and tempering of nitrogen austenite (3) or reactive deposition of iron in a nitrogen atmosphere.(4,5) Innovative, new concepts for preparing these nitride systems, either separately or as a composite exchange-coupled (spring) magnet (6,7) are being sought.

PHASE I: Investigate and demonstrate innovative approaches for the production of high-performance, nitrogen-based magnets of Sm2Fe17Nx , alpha-Fe16N2, or composites that combine the two phases to produce an exchange-coupled magnet.

PHASE II: Implement the innovation, which should include the production and testing of prototype magnets. Explore major cost and reliability issues associated with the innovation in the context of commercial viability.

PHASE III: New nitrogen-based compounds offer very attractive hard (Sm2Fe17Nx) and soft (alpha-Fe16N2) magnetic properties. These magnets could potentially displace a large fraction of materials currently being used in compact electric motors, magnetic recording heads, power generation equipment/ transformers, and high-temperature magnetic bearings. Each of these areas represent major markets that could be impacted. An optimized composite that mixed the two phases could lead to an exchange-coupled magnet that would significantly out perform any permanent magnet currently on the market. Unfortunately, conventional processing methods are not amenable to these materials. This research is intended to provide the processing breakthroughs that facilitate the commercial development of these new classes of high performance permanent and soft magnets.

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KEY WORDS: Processing nitrogen-based magnets, permanent and soft nitrided magnets, exchange coupled spring magnets.

A01-042 TITLE: Web-based Techniques for Remote Scientific Visualization

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: CHSSI/PET High Perf. Computing Monitoring office

OBJECTIVE: Development of Web-based Scientific Visualization tools to aid in the analysis of High Performance Computing (HPC) simulations. These tools must be able to adequately visualize typical HPC simulations during runtime and after completion.

DESCRIPTION: High Performance Computing (HPC) simulations have proven to be an irreplaceable tool in the design of new materials and weapon systems. To accurately interpret the results of these simulations, Scientific Visualization has emerged as one of the best ways to represent the intermediate and final results. With the enormous amounts of data regularly generated during High Performance Computing simulations, transferring significant amounts of data to remote machines for post-processing must be minimized. In particular, Scientific Visualization requires significant memory and processing resources to adequately provide insight into complex and enormous datasets. Transferring enormous amounts of data to a desktop workstation is impractical.

Traditionally, "visualization servers" that process datasets too large or complex for desktop workstations meet these requirements. When feasible, the polygonal output of the visualization if transferred to the desktop for final rendering. Since three dimensional data is being transferred, additional geometric manipulation of the data by the user requires little to no further communication with the server. This method works well enough until even the original number of polygons becomes too large for the desktop.

Emerging methods for solving this problem include off screen rendering of polygonal data and volume visualization techniques. In both situations, only a final rendered image is transferred to the desktop. While additional geometric manipulation by the user requires additional communication, image compression can help minimize the cost.

To simplify access, it would be advantageous to allow for standard web browser access to these facilities. By utilizing secure access methods and authentication, web aware visualization servers could execute on machines capable of performing the necessary visualization tasks. Using functionality available on all major browsers, graphical user interfaces can be used to construct a user request for visualization. Parallel visualization techniques can then be used to produce an image in response to the request, which is then returned to the user.

PHASE I: The contractor must develop an implementation strategy that can and will result in a system with the following characteristics:

1. Be secure
2. Be capable of generating isosurfaces, cutting planes, streamlines, and volume visualization
3. Be able to operate on single structured datasets of over 20 million nodes and unstructured datasets of over 2 million elements.
4. Be able to visualize time varying datasets
5. Execute on a variety of platforms
6. Require only limited capability from the user\222s browser
7. Be flexible enough to take advantage of emerging Web technologies

PHASE II: The contractor shall develop the proposed system and test the tools as they are developed with supplied representative datasets. Under a variety of load conditions and network connections, the contractor will demonstrate that all tools meet or exceed the criteria of PHASE I.

PHASE III: The final product will have a wide range of application to HPC simulations. Computational Structural Mechanics, Computational Chemistry, and Computational Fluid Dynamics are just a few technology areas that will benefit from the development of these tools.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Development of these tools will greatly reduce the time researchers spend during HPC simulations. This will have a positive impact on the development time of new weapon systems.

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KEYWORDS : High Performance Computing, Remote Scientific Visualization, World Wide Web

A01-043 TITLE: Visualization of Emerging Complex Events in Urban Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Identify techniques for visualization of early warning indicators of dynamic, emergent (i.e., unfolding, non-linear) conditions during the execution of military missions in urban environments. The general area of interest is how the human inference process is impacted during information analysis and decision-making by rapidly unfolding and non-linear real-world events. The goal is to design and develop a prototype software tool to assist military intelligence analysts in detecting emerging patterns and situations during urban operations. The tool is intended to support cognitive integration and visualization in support of improved situation understanding and decision-making.

DESCRIPTION: New technologies, concepts of operations, and organizations promise to increase the speed, agility, and precision of military systems. However, few of the current or proposed systems address the difficult cognitive tasks associated with recognizing, assessing and cognitively integrating dynamic and multi-variate events such as those present in urban operations. What are required are technical capabilities that enable rapid, adaptive and decisive actions during missions where future events can be influenced by small changes in the environment. They should also enable the detection and correct interpretation of situations, both friendly and enemy, where situations or actions may limit military effectiveness. By recognizing the early indicators of these conditions, strengths can be exploited and weaknesses corrected. Timely recognition and analysis of such indicators in adversary forces will enable the decision-maker to counter or exploit such behaviors in adversary forces. The intent of this work is to develop and prototype a computer-based visualization tool to support human inference and cognitive integration processes during rapidly changing urban operations. The tasks to be performed during Phases 1 and 2 are described below.

PHASE 1: Using insights and methods from Complex Adaptive Systems research, identify early warning patterns and indicators that indicate to intelligence analysts and decision-makers the presence of dynamic and complex events of interest in urban operations. From a selected set of significant warnings and indicators (obtained from military subject matter experts), propose promising computer-based techniques (e.g., genetic algorithms, ecological models, cellular automata, etc.) that will support the understanding and visualization of an urban area of operations. Finally, select the most promising technique or set of techniques and propose an applicable and feasible prototype proof-of-concept.

PHASE II: Based on successful results of Phase 1, develop and demonstrate a prototype system based on a realistic urban scenario incorporating complex military, environmental and civilian conditions and interactions. This prototype will leverage advanced display technology and provide an underlying structure to identify, cluster and prioritize and present data and information as they unfold.

PHASE III: This system could be used in a wide range of military and civilian applications where the detection of non-linear patterns is critical to mission or organizational success. For example, in military and civilian intelligence and security and police applications, counter-terrorism and anti-drug operations, and epidemiological and social research to detect trends in a variety of indicators of interest where complex interactions are common.

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KEY WORDS: Complexity, Emergence, Pattern Recognition and Analysis, Urban Warfare.

A01-044 TITLE: Solid State Source Combined Amplifier for Communications or Radar Application

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PM, MILSATCOM

OBJECTIVE: To provide a compact, low cost solid state source of electromagnetic radiation at Ka-band suitable for communications or radar applications.

DESCRIPTION: Moderate power levels at Ka-band from solid state sources require the combining of individual solid state devices or MMIC's (microwave/millimeter wave monolithically integrated circuits). Such combined sources offer the opportunity for highly linear sources of power with very low phase noise. The solid state technology provides the potential for

highly reliable systems with long mean times between failure. The combining of many source elements provides the opportunity to insure that when failures occur, the system has a graceful degradation mode. Spatial (and quasi-optical) power combining techniques [1-4] and circuit based power combining techniques [5-7] have been demonstrated over a range of frequencies. However, the application of these techniques to a power amplifier component suitable for cost effective applications in point-to-point or satellite communications systems or in radar systems is a significant technical challenge. The amplifier component must use waveguide input and beam mode output. Performance goals are: 10-20 watts (at the 1 dB compression point) in the frequency range range 28-45 GHz, with at least 9 dB small signal gain, 100 watts third order intercept (TOI), a 3.5% bandwidth, and phase noise less than -140 dBc/Hz at 10 KHz. Power added efficiency should be 20% or higher. For low cost manufacturability the integrated circuits must be single chip MMIC's or multichip module (single substrate) hybrids. Commercially available MMIC's must be used or the integrated circuits must be compatible with a commercial foundry process, such as the Triquint process. Effective thermal control must be integrated with the amplifier. The cross section perpendicular to the direction of beam propagation should be less than 3 wavelengths by 3 wavelengths, with overall volume and weight critical issues.

PHASE I: Demonstrate the technical feasibility of the approach using a combination of experimental results and physical modeling. The technical goals and requirements may be relaxed provided credible modeling demonstrates the scalability of the approach.

PHASE II: Provide a technical demonstration of an amplifier component meeting the goals and requirements and presenting the basis to develop a low cost manufacturing design.

PHASE III: The resulting amplifier component will have applications in military and commercial point-to-point communications systems and satellite up-links, where the increased power will enable higher data rates and better rain margins. It will also have applications in military radar systems, with an emphasis on low phase noise, low cost, and high reliability.

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KEYWORDS: Power combining, Ka-band amplifier

A01-045 TITLE: Silicon Carbide-Based Multiphase Composites for Advanced Armor Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: TACOM-TARDEC

OBJECTIVE: Develop a powder-based processing approach for the manufacture of silicon carbide-based multiphase composites with Vickers hardness values greater than 28 GPa (10+ kg load in accordance with ASTM C1327), isotropic mode I fracture toughness values greater than 7 MPam1/2 (Single-edge Pre-cracked Beam, ASTM 1421) and densities no greater than 3.5 g/cm3. Furthermore, the restriction on manufacturing cost is that it they must be within +50% of a current state-of-the-art silicon carbide for suitably large plate geometries (minimum 10 cm x 10 cm x 2.5 cm) and quantities.

DESCRIPTION: The performance of ceramic armors depends heavily upon the intrinsic ballistic characteristics of the ceramic. Silicon carbide ceramic armor technologies offer mass and space efficiencies superior to other ceramic-based armor against medium-caliber armor-piercing threats. This is due not only to silicon carbide's lower density, but also because of its superior hardness, tensile strength, and fracture toughness.

The proposed protection/weight goals for the U.S. Army's future combat system (FCS) land vehicle indicate that today's conventional armor-grade silicon carbide ceramic armor technologies will not be sufficient. In addition to improvements achievable through advances in system design, improvements in the intrinsic performance of silicon carbide will be required. Thus the need for an accelerated effort to develop next-generation armor ceramics that have improved toughness and hardness to meet the desired protection goals, as well as density less than or equal to silicon carbide in order to meet the required weight goals.

In spite of the lack of ability to predict ceramic ballistic performance based on specific physical and mechanical properties, it is generally accepted that properties such as bulk modulus, Poisson's ratio, hardness, and fracture toughness play important roles. In particular, hardness can be viewed as an indicator for a material's ballistic potential, while toughness is an indicator for the realization of this potential. Except in the case of chemical energy threats (e.g., shaped charges), a material with a low hardness will exhibit low ballistic performance no matter what its toughness. Similarly, a material with a high hardness and low toughness will under perform. Consequently, a material with both high hardness and high fracture toughness would be expected to yield high ballistic performance.

During the previous three decades, research on the influence of microstructural heterogeneity on crack-propagation resistance led to the development of high toughness ceramic-matrix and multiphase ceramic composites. However, with few exceptions, increases in toughness have been offset by corresponding decreases in hardness. As a consequence, previous ballistic evaluations of toughened ceramics have yielded mixed results for the reasons specified above. Therefore, the ballistic requirement is to increase both hardness and fracture toughness at the same time. The goal of this work is to develop multiphase ceramics based upon silicon carbide with both increased hardness and fracture toughness, with the restriction that their densities be nearly equal to that of monolithic silicon carbide.

PHASE I: Identify the most promising phases and their form (i.e., powder, particulate, whisker, etc.) for composite formation with alpha silicon carbide (parent phase). Based upon the density constraint, develop a Taguchi-based experimental investigation of processing parameters to achieve density and chemical compatibility goals. Processing parameters may include silicon carbide particle size and distribution, volume loading and form of secondary phases, sintering additives and quantities, powder and green-body preparation techniques, time-temperature sintering or hot-pressing cycle parameters, etc. Conduct preliminary investigations of the appropriate processing parameters to produce fully dense multiphase ceramics. Develop a screening methodology for quick evaluation of hardness and fracture toughness. Demonstrate the feasibility to produce fully dense silicon carbide-based multiphase composites having Vicker's hardness greater than 24 GPa and fracture toughness greater than 5.5 MPam1/2.

PHASE II: Conduct a refined investigation of processing parameters required to produce multiphase ceramics approaching the desired density and hardness/toughness goals. Evaluate hardness and fracture toughness on fully dense composites. Conduct an optimization study (based upon the requirements for density, hardness, fracture toughness, and cost) on the most promising composite systems. Demonstrate one or more silicon carbide-based multiphase composites that meet the specified requirements for hardness, fracture toughness, density, and cost. Demonstrate scale-up feasibility to produce tile sizes to > 10 cm x 10 cm x 2.54 cm.

PHASE III: Scale-up processing to produce sufficiently large tiles for full-scale armor testing. Based on ballistic results, scale up process to manufacture armor tiles for protection of U.S. Army, other Department of Defense services, and other law enforcement agencies' vehicles.

COMMERCIAL POTENTIAL: Both law enforcement and the protective services industry would be interested in more efficient vehicle armor. These materials could benefit both public and private armored vehicles used for humanitarian demining and unexploded ordnance cleanup. Silicon carbide-based ceramics are used extensively in numerous high temperature industrial processes, as wear-resistant materials, and in the electronics industry.

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KEYWORDS: Multiphase ceramic, armor, silicon carbide, ballistic, hardness, fracture toughness, Future Combat System, FCS

A01-046 TITLE: Cold Gas-Dynamic Spray to Improve Structural Integrity and Ease of Repair

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this effort is to support Lethality by the development and demonstration of the cold gas-dynamic spray process for applying metals, intermetallics and cermet powders to metallic and ceramic substrates for such applications as gun barrels and free formed near-net structures such as mortars to improve wear resistance and reduce weight. Several investigators have already successfully demonstrated material deposition by cold spray methods. Compared with thermal spray technologies, cold-sprayed metals demonstrate significantly higher electrical and thermal conductivity, are very dense, highly wrought and can be used to form free-standing metal structures. Cold-sprayed surfaces could be developed using new combinations of materials that exhibit improved wear and corrosion resistance without environmental liabilities such as volatile organic compounds and sludge disposal such as are found in paint and electroplating operations. This technology has many potential surface engineering applications including building electrical circuits into structures, repair of metal parts in the field, joining dissimilar materials (ceramics and metals, glass and metals), and improving wear on surfaces in intimate contact and corrosion resistance on components exposed to hostile environments.

DESCRIPTION: Thermal spray technologies are the dominant technologies used in surface engineering applications today. Thermal spray technologies rely on the coating material (wire or powder) to become molten before it is sprayed onto a surface. In the process of melting the coating materials, the metals oxidize and the resulting metal oxides reduce the materials electrical and thermal conductivity as well as create material property problems such as lower yield strength, reduced modulus and increase brittleness. Thermal sprayed surfaces are often fairly porous and have large grain structures making them subject to corrosion and wear. Thermal processes also limit the substrates that can be sprayed since many substrates are heated by the process and undergo phase, oxidation and other undesirable changes such as dimensional changes and warpage in thin parts. Further, the resulting thermal contraction can produce significant residual stresses in the complete part. Cold-sprayed materials are not heated to a molten state and therefore don't oxidize. Rather they are deposited by plastically deforming onto the substrate. Since coatings are applied at near room temperatures substrate heating problems are avoided. Certain metals and alloys can be built up in multiple layers of inches and exhibit properties of the nascent metal and appear as metallurgical bonds. Other materials can only be deposited in a single layer and not built up while other metals can be deposited onto dissimilar materials such as ceramics or glass (thus clearly not having a metallurgical bond). Cold spray bonding mechanisms are not well understood.

The deposition process can be either portable or stationary. It can be performed in a closed environment or outside for large products, such as tubes of large diameter and length, and ships, aircraft, ground vehicles, weapon systems, and bridges. Cold spray technology has great potential for restoring the geometric dimensions of worn parts in the field.

PHASE I: Demonstrate the feasibility of using cold gas spraying processes for one or more of the following applications commonly used by the military and industry; coating/joining dissimilar materials (ceramics/metals, glass/metals, glass/ceramics, etc.), repair damaged parts, improve corrosion resistance, improve ware resistance, increase thermal conductivity and/or electrical conductivity, improve insulation properties (electrical/thermal), improve surface hardness and/or structural properties. In Phase I, a specific application of value to the U.S. Army shall be identified and demonstrated by spraying substrate materials. The economics of the process should demonstrate commercial viability and advantages over existing thermal spray or coating techniques. Example: An application of interest to the Army is fabricating the rotating bands on the Excaliber projectile with a material so that the rifling inside the barrel of the gun is not destroyed when it is fired and the structural integrity of the projectile is maintained through the launch process.

PHASE II: The feasibility tests demonstrated in Phase I above shall be expanded and applied to a piece of hardware, device, equipment, system, vehicle, or weapon used or deployed by the U.S. Army. The coating shall be validated by testing it on the device or system on which it is being deployed. The integrity and reliability of the coating (bond strength, ware resistance, electrical conductivity etc.,) depending on application shall withstand extreme duty cycles, be cost effective, environmentally sound, and improve on current technologies. Example: Fabricate the rotation band on the Excaliber projectile using the cold spray process and test by firing a number of projectiles through the gun barrel to validate barrel damage and projectile structural integrity.

PHASE III: Numerous commercial applications exist with the cold spray process that can be applied for use in the aerospace, automotive, chemical, electronics, manufacturing, and medical industries to name a few. These include spraying a hard surface on the valve seats or on the cylinder walls of internal combustion engines or turbine blades to maximize ware, spraying aircraft landing gear, aluminum wheels, process piping, and weld seams with nickel or stainless steel to improve corrosion resistance while reducing weight, applying electro conductive metals such as aluminum, tin, copper, gold, and silver onto insulators such as circuit boards, glass, ceramics, or plastics to form electrical conductive paths, fabricating high current electrical contacts, applying magnetic coatings for use in sensors and instrumentation, titanium and stainless steel can be sprayed to fabricating medical implants, plastics can be sprayed with metals to minimize static electricity, dissimilar materials (ceramics and metals) can be joined together to provide a structural bond or pressure/vacuum seals. Further, the spray equipment can be made portable to perform field repairs on damaged components such as aircraft structures, sheet metal, and structural components. With these applications, the cold spray process will lead to broad diffusion into commercial markets.

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KEYWORDS: cold spray, cold gas dynamic spray process, metal coatings

A01-047 TITLE: Nonlinear Transmission of Laser Radiation for Eye and Sensor Protection

TECHNOLOGY AREAS: Materials/Processes, Biomedical, Human Systems

OBJECTIVE: Recently a significant breakthrough has been made in the science of "Reverse Saturable Absorber" (RSA) molecules which were used to obtain optical pieces that have demonstrated the potential for the further development of the S&T to arrive at functionally acceptable Optical Limiters (OLs). Such results have been discussed at scientific meetings such as that of the SPIE in the open literature. New classes of these RSA materials have also been discovered with significant optical nonlinearities that can be put to use for Optical Limiter applications. Both the science and the materials technologies do need further frontier work to turn this knowledge base into practicable OLs for both civilian and DoD applications. As the availability of higher and higher power lasers increases, the threat to the civilian sector applications will require correspondingly new safety "goggles". The science of "Photo-Chemistry" is also advancing to a point that a wide range of laser frequencies will be needed to control specific sets of chemical processes. A functionally satisfactory OL for one or more of these applications will in turn help the evolution of the S&T in this field with benefits to both the civilian sector and the DoD. The Objective of this SBIR topic is to couple frontier science to that of technology and produce functionally acceptable (see criteria below) prototypes which can be easily manufactured in large numbers.

DESCRIPTION: To carry out basic and applied research in science and engineering and produce prototype OLs based on RSA molecules in appropriate hosts, such that the resulting OLs are functionally acceptable (see criteria below) and are practical in the sense of manufacturability and marketability. The manufactured benchmark optical limiters will have to protect eyes and sensors from laser radiation, with optical intensity reduction factors of three orders of magnitude or more using the RSA molecules. Visibility through such OLs will be without optical distortions and their transmission will be 65% or more of the ambient light, at normal ambient light levels with linear response up to the intensity of scattered (non-direct) sunlight intensities. To prevent damage to eyes by laser radiation, the dynamic response of the OLs will be such that they will cut down the intensity of nanosecond laser pulses by three or more orders of magnitude, down to less than a microjoule. The OLs will recover their linear transmission equally as fast upon the termination of the laser pulse propagation through them. The OLs themselves will not be damaged by the laser radiation so that they can be used continuously without the need to replace such units in optical trains. The OLs will be physically robust/immune to mechanical shock and to the extreme military environmental temperatures. They should be insertable into existing optical trains.

PHASE I: The physics and chemistry of the RSA molecules, down to the energy level structures will have to be gleaned from the spectroscopic details of the energy level excitation and de-excitation processes in time-resolved fashion. The sources of the linear and nonlinear optical behavior have to be researched and understood in terms of microscopic quantum mechanical processes as appropriate. The experimental and theoretical work will be combined to model the nonlinear optical behavior of RSA molecules and applied to achieve the above stated OL behavior over much of the visible spectrum. The IR region of the EM spectrum is not

addressed in this SBIR, nor is the S&T of liquid crystals. Manufacturability of the OLs, and their operability in military scenarios will also be incorporated into the R&D in this phase, arriving at a totally integrated research-to-technology conversion plan based on the findings of this phase of the project.

PHASE II: The knowledge base obtained in Phase I will be further refined in this phase arriving at a set of delivered prototype OLs at the end of this phase; these deliverables must be functionally acceptable according to the criteria specified above. A first set of such OLs delivered should be usable for civilian applications, such as those in hospital operating room environments, in robotic manufacturing environments and beyond. A second set of delivered OLs must be capable of protecting our warriors' eyes and their sensors against laser radiation damage in vulnerability situations in the battlefield. Patent disclosures will be made as appropriate.

PHASE III: A concerted effort will be made by the offerer to find commercialization for the OLs in the civilian sector. Such applications as reduction of glare in photography, safety of the eyes of surgeons, factory workers and of surveyors will be sought. Such applications will be tested with the Phase II prototype OLs and market potentialities will be assessed. Patent applications will be submitted as appropriate.

REFERENCES:
Refer to the proceedings of several of the recently held SPIE meetings, such as the San Diego one this past Summer and the one held in Denver earlier.

KEY WORDS: Nonlinear transmission; nonlinear optics; reverse saturable absorbers; optical limiters; excited state absorption bands, phonon pathways; excited state absorption, radiative and non-radiative decays; nanosecond, picosecond, femtosecond spectroscopies; time and frequency resolved spectroscopies; quantum mechanical calculation of energy levels and transition probabilities; damage threshold, eye safety, sensor protection; infra-red and visible ranges of the electromagnetic spectrum; liquid crystals; optics manufacturing technology; market analysis.

A01-048 TITLE: Burst Mode, High Data Rate Communication Links with Narrow Beam Directional Antennas

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To design and develop a burst mode, high data rate, full duplex communication link at mmW frequencies.

DESCRIPTION: A multi-function RF sensor capability for Future Combat System has the potential of providing both communication and radar capabilities minimizing the electronics' infrastructure in terms of space, power and cost. A reasonable solution sought out is the use of multi-beam shared aperture electronically scanned antennas (ESAs). The benefit of an ESA is the rapid and selective positioning of narrow antenna beam(s). In regards to radar this enhance beam control feature allows both selective surveillance and tracking modes. A radar function includes both transmitting a known waveform and processing return signatures over an allotted radar timeline. The area is further bounded by the narrow antenna beam illumination. The communication challenge is quite different and perhaps more challenging in the context of using directional narrow beam antennas. The first challenge is establishing the initial link between two RF systems using narrow beam ESAs. Unlike most omni-directional communication systems, aligning the separate antenna positions is a major obstacle to overcome. This involves establishing reasonable location positioning and hand shaking linkage protocols. When a link is established, the radar timelines and the desire of not being detected will limit the rapid exchange of a large amount of data. The clear advantage of a communication system that uses a directional narrow beam antenna is in the benefit of achieving a lower probability of intercept (LPI). LPI is further enhanced by the selection of spread spectrum waveforms. Yet even under the LPI condition, the fundamental aspect of establishing a burst mode, high data rate two-way communication link is then ultimately defined by the receiver detection's ability to respond. Therefore, not only are the protocols important but modulation selection and the development of appropriate high-speed carrier and clock recovery circuitry.

PHASE I: Research, explore and design modulation and demodulation architectures to support burst mode (< 10 usecs), high data rate (> 100 MB/s) full duplex mmW (Ka band) communication links. Establish initiating linkage procedures using narrow beam antennas (<3 degrees) within line of sight ranges (<2km). Designate modulation and demodulation architectures that also support LPI requirements.

The contractor must demonstrate architecture validity through modeling and simulations.

PHASE II: Build and Prototype associated modulator and demodulator that verify simulation models. Investigate custom-off-the-shelf solution like field programmable gate arrays or identify, design and build required ASICs. Develop protocols and test narrow beam linkage scenarios.

PHASE III: As our communication needs expand and the frequency spectrum continues to be over loaded in these lower frequency bands, mmW appears to be the logical band for future communication needs. Therefore these communication module can have a profound effect on future commercial applications.

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KEYWORDS: Spread spectrum, Clock recovery, Carrier recovery, PSK, FSK, Modulator, Encoder,Demodulator, Decoder, Link budget

A01-049 TITLE: Wireless Binaural Microphone for Distant Monitoring

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop a wireless binaural microphone (WBM) system for directional monitoring of distant acoustic environments. The system should work as an acoustic receptor only, or as a part of an audio-visual system. The WBM system should consist of two or more microphones, have nominal directional characteristic of a typical human head, and provide a means for changing directionality and sensitivity of the microphones. The system needs to be equipped with a spatial audio human interface for continuous environment monitoring and be able to provide feedback regarding the actual settings of the WBM to the operator. Direction of the WBM should be controlled by the head position of the operator with precision not less than 2 degrees and minimal time lag.

DESCRIPTION: Directional information about the dynamically changing acoustic environment is critical to military mission execution and force protection. This information may supplement visual information or can be used on its own merit. Existing multiple single-sensor acoustic signal recognition systems are capable of providing information about position and gross behavior of an acoustic source but are not sophisticated enough for acoustic signature identification and speech recognition. They are also expensive, stationary, and cannot be used by a moving military force. Human hearing provides required capabilities but its range is limited. There are also many situations where information needs to be gathered using remote-controlled sensors and robotic vehicles. Therefore, there is a need for acoustic sensors that simulate human hearing and can be mounted on remote-controlled robotic vehicles or placed at or launched to specific locations. Spatial audio interface to such a simulator is needed to facilitate real-time auditory monitoring of the environment by the operator in the manner consistent with monitoring that could be provided by a hypothetical soldier placed in the respective location. Therefore, sensitivity, resolution, and directional capabilities of the microphone system should approximate those of the human hearing. Additional capabilities of the system such as noise reduction and selective signal filtering should be considered.

PHASE I: The objective of Phase I is to perform a system engineering study and to provide a hard-wired working model of the system using commercially available components. The goal of the model is to provide proof of concept and to determine functional capabilities of the future system. Form of packaging and miniaturization of the future system should be addressed in the final report.

PHASE II: The goal of Phase II is to develop and provide a fully functional wireless prototype of the system. Complete documentation is considered a part of the prototype. Performance of the system shall be demonstrated in the outdoor environment at a distance not less than 200 m. Capability of the system to be interfaced with existing military radio systems should be addressed and demonstrated.

PHASE III: The system is expected to expand to the current commercial market. The system should have direct applications to rescue operations (e.g. earthquake rubble search), commercial and government security systems, and remote monitoring of group activities. It will also have large scientific application for monitoring and recording activities of various species without disturbing their natural habitats.

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KEYWORDS: Wireless, Binaural Microphone, Distant Monitoring, directional monitoring, acoustic receptor, spatial audio human interface, remote target acquisition

A01-050 TITLE: A Fiber Optic Biosensor for Detection of Organophosphorus Compounds Using Langmuir-Blodgett Film Technology

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: To design a simple, effective, stable, sensitive and reusable sensor for the detection of organophosphorus compounds using Langmuir-Blodgett films of acetylcholinesterase (AChE).

DESCRIPTION: Organophosphorous (OP) pesticides and nerve agents are known to cause severe toxic effects in animals and human beings (1-2). Hence sensitive, rapid and reliable detection of these compounds, and the development of suitable decontaminant systems are very important for the protection of the environment and human health. The mode of action of these compounds has been ascribed to their ability to inhibit AChE. Enzymatic sensor methods based on the inhibition of the activity of enzymes have been the subject of intense investigation due to their sensitivity and specificity (3-5). Biosensors for the detection of these OP compounds, based on acetylcholinesterase (AChE) activities as molecular recognition elements were combined with a variety of transducers. However, certain characteristics such as the response time, sensitivity and reusability of the sensors can be improved by using Langmuir-Blodgett (L-B) film technology (6-7). L-B film technology is a powerful tool to develop organized monolayers of supramolecular complexes including enzymes. The L-B film technology allows convenient creation and deposition of oriented protein films with a high density of active sites of the enzyme molecules. It offers the advantage of tailoring sensitivity of sensors via control of the number of deposited films. It also offers a reproducible casting of the receptor layer.

PHASE I: Develop the design of an optical fiber Langmuir-Blodgett film sensor using acetylcholinesterase in the sensing component. Phase I investigation will include demonstration of the formation of stable monolayers of AChE and reactivation of the OP inhibited AChE in the presence of a nucleophilic agent [trimethyl bis –(4 formylpyridinium bromide)dioxime]TMB-4. The design studies must also determine the optimum conditions for the transfer of monolayers of AChE to an optical fiber and develop spectroscopic methods to follow enzyme activity with OP compounds. The technique developed should be designed in a manner as to accomodate all those enzymes related to acetylcholinesterases and allow for probing of the many different inhibitors (carbamate pesticides, various quaternary ammonium compounds and substituted acridines and phenothiazines).

PHASE II: Define and refine the preliminary design; develop a prototype L-B film fiber optic biosensor that is sensitive and resuable. Critically, the means to monitor the activity of the system in the presence of different concentrations of OP compounds must be developed. Key components to be addressed include characterization of response time, reproducibility, stability, and the optimum working conditions, such as pH, temperature, sample size, and medium manipulation techniques.

PHASE III: Phase III includes further development of the specificity of the technology for utilization and commercialization. The proposed technology would be directly applicable to the detection of OP compounds in the battlefield and domestic contamination sites. Organophosphorus compounds are generated in substantial quantities in the private sector and have lead to the contamination of ground water from organophosphorus pesticides or waste streams generated by industry. The similarity of chemical agents to commercially important organophosphorus products means that the techniques developed in this topic are directly applicable to industry.

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KEYWORDS: chemical warfare agents, protection, detection, enzyme, toxic industrial chemicals, chemical/biological warfare agents, Organophosphate, organophosphorus, fluorescence, biosensors

A01-051 TITLE: <u>Enhancement of Biometrics with Advanced Pattern Recognition Techniques for Information Systems Applications</u>

TECHNOLOGY AREAS: Information Systems

In recent years, many biometrics systems have entered the market. These systems are mostly used to allow access to personal computer systems and facility access systems. They have not yet made their way into tactical information systems, which are typically distributed, dispersed, and narrow bandwidth. Research is therefore needed to apply advanced analytical techniques to make the next generation biometrics systems that provide a high degree of confidence to users. With the maturity of technology, opportunities for commercial applications to business, financial, and intellectual property systems also open up.

OBJECTIVE: The objective of this initiative is to develop an analytical and quantitative basis for biometrics sensor devices and authorization systems for application to critical, tactical, distributed, and networked information systems.

DESCRIPTION: Information dominance is a key objective of the Twenty-first Century Army. Information dominance is attained by providing information to our warfighters as they need it. Additionally, we have to protect our information from being accessed by unauthorized people, whether they are friends or adversaries. Another aspect of protection consists in controlling access to tactical systems. Traditionally passwords are used to protect critical systems.

Biometrics is promoted as an alternative to passwords and is highly regarded as a "single sign-on" to gain access to several networked systems. Fingerprint identification, iris scanning, hand imprints, and speaker identification are among the leading contenders for biometrics authorization schemes. Although a number of systems are presently on the market, they are deficient in reliability, repeatability, and robustness. In tactical information systems applications, missions will be jeopardized when a genuine user is denied access or when an imposter is allowed access due to unreliable performance of a biometrics device and system. Biometrics devices and systems have to be developed to a high degree of accuracy. That means that the probability of identification of a genuine user should be very high of the order of one in a million error rate. Their probability of misidentification of an imposter as a genuine user should be infinitesimally small, i.e. one in a million error rate. Commanders should be able to choose the degree of error they will tolerate in allowing access to their systems during tactical operations. Commanders do not like to wait to obtain authorization of a person to use a system by a remote server via low bandwidth communication channels. On the other hand, if a weapon system falls into the hands of the enemy, the commanders will not like it to be used by the enemy. This dual criteria is perhaps attainable by segmenting a biometrics image into several parts and developing a confidence factor as more segments match.

If for example we examine a fingerprint, there are several dozen contours in it. If we build a system that identifies each contour and as more contours match, a greater degree of confidence is assigned to the person seeking entry to a system. By further segmenting the contours, we can get more elements to compare and a finer grain of comparison can be achieved.

Traditional biometrics systems employed by law enforcement agencies merely automated methods originally devised for human identifiers. Published literature in the automated target recognition area offers many robust methods of pattern recognition. Improvements are needed in the current biometrics devices and systems by incorporating pattern recognition techniques, algorithms, and protocols employed in the image processing area. The contractor may wish to use PCASYS (see reference) distribution, which consists of source code, data files, and a demonstration set of 2700 fingerprint images.

Typically, here are the areas in which improvements are sought:
Device tolerance to disorientation of the subject (for example, a finger or an eye) with respect to the sensing device in providing biometrics signatures,
Device tolerance to atmospheric, environmental, and usage conditions,
Pattern recognition algorithms, techniques, and protocols such that partial and imperfect images can yield accuracy of identification of a genuine user,
Testability of sensing mechanisms (devices) in isolation as well as in combination with application systems,
Faster response times for sensing systems (including communications),
Methods of storage and transmission of master images or encrypted representations of master images, and
Methods of transmission of user images and signals
Encrypted representations of images.

PHASE I: Investigate the current public domain biometrics techniques and algorithms and compare them to advanced pattern recognition techniques applied in target recognition applications. Investigate the feasibility of detection with partial images and developing metrics for increased confidence in images. Identify biometrics sensor designs that are invariant to user errors.

PHASE II: Design, build, and apply breadboard sensor devices to tactical Army Information systems applications. Devise methods to transmit partial images of pre-selected templates for comparison against distributed repositories of templates.

PHASE III: Identify and apply designs of biometrics sensors to commercial applications such as financial institutions and security industries.

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KEYWORDS: Biometrics, fingerprints, iris images, automated target recognition, pattern recognition

A01-052 TITLE: Opto-Silicon-Integrated System for High-Resolution Real-Time Image Quality Analysis

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: US Army Aviation & Missile Command

OBJECTIVE: Develop an opto-silicon-integrated [Charge Coupled Device (CCD), Complementary Metal Oxide Description, Semiconductor (CMOS), Very Large Scale Integration (VLSI), optical Micro Electrical Mechanical Systems (MEMS), etc.] system for high-resolution fast parallel image quality analysis. A large number of image processing applications require fast detection and enhancement of image edges and rapid image quality analysis. In the future smart vision systems, fast on-the-fly image edge detection and image quality analysis will allow for the use of image quality metrics for real-time atmospheric turbulence-induced wavefront phase distortion correction using adaptive optics techniques. Additionally, with computer/machine vision systems image quality metrics including edge-maps are used to define object boundaries so that robotic manipulators can properly identify the target. For image processing applications speed and resolution are the major factors upon which the entire system's performance depends. In target tracking and recognition applications, edge detection and image quality analysis are used to suppress redundant background information and thereby reduce the volume of data which must be processed by downstream electronics. In either of these applications, the edge detection and image quality analysis are typically accomplished through a

time-consuming sequence of filtering and threshold detection steps, resulting in low resolution/frame rate image processing. The specific objectives of this program are to develop high-resolution light-sensitive integrated optical or opto-electronic systems (cameras) for fast on-the-fly image quality analysis.

DESCRIPTION: The system developed under this program should achieve the process of raw image, edge and image quality metric/map detection at rates of 300 frames per second and higher, and must be able to sustain image resolutions of 256x256 or greater. Image quality metric map detection should include the following real-time image processing: background (edge-image frame mean level) subtraction, parallel modulus (square) calculation, automatic gain control, and convolution of the processed edge-image with a spatial filtering kernel. Image quality metric calculation includes the spatial integration of the image quality map. The system should operate under conventional outdoor white light illumination conditions typical for ground-to-ground imaging.

PHASE I: Demonstrate feasibility, design and develop a prototype edge-detection system with 256x256 resolution and frame rates up to 60 frames per second.

PHASE II: Redesign the system to allow real-time image quality map and image quality metrics calculations at rates up to 300 frames per second. In addition, the system should be designed to allow for user programmability of the specific computational functions and frame rate control. Develop and demonstrate commercial and military applications, and leverage market opportunities.

PHASE III: MILITARY: The opto-silicon-integrated system should allow for the future integration of optical elements, digital interfaces, computer and driving electronics into a single unit. This will result in wireless, small size, low power, high-performance intelligent devices suitable for applications including real-time small target tracking and recognition, aberration-free imaging (adaptive binoculars, sniperscopes, etc.), reconnaissance imaging, and military robots. NON-MILITARY: Recognition and identification systems for industrial applications, free-space communication, and industrial robots.

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KEYWORDS: Adaptive optics, image processing, target detection, target tracking

A01-053 TITLE: <u>Flow Noise Reduction for Acoustic Sensors on Robotic Vehicles</u>

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective is to develop a robust technique to continuously and adaptively reduce or filter out the flow noise, due to vehicle motion, of a mobile robotic vehicle. The reduction of flow noise technique should improve the SNR and restore the acoustic sensor's effectiveness in detection, localization and classification of targets of interest at tactical ranges. The technique should be platform and terrain independent and can be adaptable to different sensor array configurations. The algorithm developed should be able to run on PC-based system. The technique should be suitable for future low-cost acoustic sensor systems and be evaluated in a field test against real target data.

DESCRIPTION: Current acoustic sensors are capable of detecting, localizing and classifying multiple targets at long tactical ranges. However, these acoustic sensors are fixed sensors and they are designed to be placed on the ground. There is a requirement to mount acoustic sensors on a mobile vehicles (e.g. HMMWV and Small Unit Operation (SUO) robotic vehicles) to detect, localize and classify other targets in the environment. The acoustic sensor's effectiveness is diminished by the motion induced flow noise and platform noise generated by the mobile vehicle. This SBIR addresses the specific problem of flow noise of a moving robotic vehicle. An improvement over existing state-of-the-art techniques is necessary to ensure long-range target detection, localization and classification capability. Innovative techniques can include (but not required): (1) advanced signal processing (2) microphone shields that can reduce effects of wind, turbulence and flow noise without altering the desired acoustic signature and/or (3) clustered microphones or area sensor.

PHASE I: Develop a technique to reduce effects of flow noise on acoustic sensors on mobile robotic vehicles. The flow noise reduction technique will be tested against real data to show improvements in microphone sensitivity over existing techniques. The newly developed technique should restore the microphone's capability to detect, localize and classify targets as part of an array configuration positioned on a moving robotic vehicle.

PHASE II: The developed technique shall be field-tested on a moving robotic vehicle provided by the government to detect, localize and classify different classes of targets. The technique shall be modified and/or redeveloped based on results obtained from this field test.

PHASE III: Any application of acoustic sensors or microphones on moving vehicles (or noisy environments) encounters the interference of flow noise with a desired signal. Emergency vehicle communications from high noise environments will benefit from improved intelligibility. Vehicle mounted microphone arrays, for "hands free" cellular phone application, will also benefit due to the reduction of undesired signals. Police vehicles equipped with microphone arrays will be able to detect and locate gun shots fired at or near their vehicles. The performance of the parabolic dish and shotgun microphones used by the news media will be greatly enhanced.

OPERATING AND SUPPORT COST REDUCTION: The cost reduction is somewhat tied in to the fact that future acoustic systems under development must be able to operate onboard moving platforms. The Army has developed many systems that use fixed acoustic sensors that must be migrated onboard moving vehicles for the detection and identification of air and ground targets, artillery launch and snipers.

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KEYWORDS: Filter flow noise, mobile robotic vehicles, noise reduction, acoustic sensor array configurations

A01-054 TITLE: Hydrogen Source for Small PEM Fuel Cell Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop new/improved methods for generating and/or storing hydrogen for use in hydrogen/Proton Exchange Membrane (PEM) fuel cells

DESCRIPTION: Small and efficient hydrogen/PEM fuel cell systems are in development to meet the need for individual soldier power for extended missions. The power range of interest is approximately 15 to 300 Watts. The main difficulty that remains to be overcome is that of development of compact units for storing hydrogen or producing that gas on demand.

For hydrogen storage, we are seeking new materials that will reversibly adsorb hydrogen at percentages greater than 4 weight percent relative to the weight of adsorbent plus container and ancillaries, with relatively low pressure and with the capability of gradual and controlled release (range of 20 to 400 cc/sec.) under conditions of reduced pressure or increased temperature. Novel forms of carbon and nanophase materials could be considered for the purpose

For hydrogen generation, we are seeking new catalysts and improved reactor design for the the reformation of readily-available hydrocarbon fuels and the identification of other chemical reactions and processes that will allow the safe, well-regulated production of gas (range of 20 to 400 cc/sec.) at a high weight percentage relative to the weight of fuel plus container.

PHASE I: Phase I will identify materials, processes and conditions that could result in the required hydrogen generator or storage unit. Initial experimentation to prepare required new materials will be conducted.

PHASE II: Phase II will include the preparation of new materials, optimization of chemical processes and the demonstration of a breadboard prototype hydrogen generator or hydrogen storage system.

PHASE III: The energy storage components under consideration here are of great potential value for use with cellular phones, laptop computers, camcorders, many other commercial electronic equipment and for civilian electric-drive vehicles.

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KEYWORDS: Hydrogen, hydrogen generator, fuel reformer

A01-055 TITLE: Biofilm Remediation for Restoration of Contaminated Army Sites

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this SBIR is to research the potential for restoration of contaminated Army sites, using stable, mixed-species biofilms in a rapid, cost-efficient process for the elimination of hazardous energetic and chlorinated organic compounds. This process needs basic research before being ready for field trials.

DESCRIPTION: The accumulation of hazardous chemicals in the Army training environment has proceeded for many decades. Restoration of the contaminated sites by elimination or removal of the substances is a high priority - but very costly - process using existing technology. Energetic compounds, such as TNT (trinitrotoluene), RDX (hexahydro-trinitro-triazine), HMX (octahydro-tetranitro-tetrazocine), and chlorinated organic compounds, such as trichloroethylene (TCE), perchloroethylene (PCE), vinyl chloride, and polychlorinated biphenyls (PCBs), are among the most recalcitrant to elimination. Microbial degradation is the most effective and least expensive alternative for remediation of environmental contaminants. Commercial proprietary systems can function in field situations to accomplish remediation of some chlorinated organic compounds, but they often fail, nor have they been used on explosive materials found at Army sites. This SBIR solicits R&D that would take advantage of the many beneficial properties of biofilms. This is a unique approach, not known to be duplicated elsewhere, that offers exceptional versatility and flexibility in the organisms that are used and the contaminants to be eliminated. In approaches currently being used, one type of microorganism will initiate the degradation to an intermediate derivative and other species complete the elimination of the accumulated compounds. However, the growth requirements for the separate organisms can be quite different, severely limiting the utility of the combined activities. This is difficult to stabilize in the usual suspension cultures employed in conventional studies using pure or mixed groups of organisms, often involving genetically engineered strains. This does not reflect the predominant microbial associations in natural environments. Consortia of multiple species of organisms associated with surfaces form biofilms, in nature, with remarkable stability and features. Studies in this relatively new area of microbiology reveal that synergism between combinations of organisms in the films accomplish complex nutritional interactions and environmental modifications that far exceed the sum of the activities of the individual species in pure, planktonic (free-swimming) cultures. Stably anchored microcommunities in biofilms have extraordinary adaptive abilities to adverse chemical and physical stresses. Their overall growth rate and survival and a preference for multiple substrates, make biofilms ideal candidates for the complex interspecies interactions required for the degradation of environmental contaminants.

Mixtures of bacteria and fungi are found growing on microbial platforms for bioremediation, yet nothing is known of the contributions of the individual species in the complex and their unique roles in the degradation of the target compounds. Contrary to being a detriment to bioremediation as is often stated, groupings of organisms could be significantly advantageous in such processes. This study would take advantage of microbial consortia to define optimal combinations of bacteria and fungi for destruction of the energetic and halogenated compounds. Heretofore, most studies of bioremediation have utilized bacterial cultures exclusively. Yet, the extraordinary degradative capacity of fungi for intricately complex organic structures is a hallmark of many fungi. The multi-species biofilms proposed for study in this project would take advantage of the cumulative strengths of the bacterial and fungal species. The results from these experiments would be used to develop practical field systems for the remediation of a variety of hazardous contaminants.

The technology to be based on these experiments would have numerous advantages. First, the process is totally natural, using indigenous organisms. Although the biofilms are stable, some organisms could escape the remediation platform, but they would be natural for that environment. Second, genetically engineered organisms would not be used, eliminating any concern relevant to

such unnatural species. Finally, the system could be allowed to run at ambient temperatures, minimizing energy requirements that often accompany the use of "laboratory" style organisms.

PHASE I: Using soil samples as inocula from known contaminated sites, mixed-species substance-degrading biofilms would be established in the presence of selected environmental contaminants.

PHASE II: The individual species from those incubations would be identified and mixed samples of known composition would be used to determine the participants in establishing the biofilms in the degradation of the hazardous substrates. Physical and nutritional conditions would be established for optimal degradative effect by the biofilms.

PHASE III: Multi-species large-sized platforms would be evaluated. It is generally recognized that there is greater efficiency in degradation in the larger operations than is seen in laboratory scale operations. Cost comparisons would be made between the newly-developed biofilm systems and conventional remediation processes.

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KEYWORDS: Bioremediation, mixed-species biofilms, energetic compounds, chlorinated compounds, site restoration.

A01-056 TITLE: A Predictive Methodology for the Effects of Chemical Agents on Materials

TECHNOLOGY AREAS: Materials/Processes

Objective: To develop a software product that can predict the effects of chemical warfare agents and decontaminants on materials for which there is no data. Using known data from related materials, and the composition of the material in question, be able to extrapolate or interpolate to predict the effects of various chemical agents and decontaminants. The final product is envisioned to be a software tool that can relate known data, extrapolated from an attached comprehensive database containing all known experimental data, to predict effects of untested materials.

Description: The use of chemical warfare agents on the battlefield has become a highly visible issue in recent years, and since the Gulf War. The number of nations possessing a chemical capability is increasing as much as the probability that the U.S. Army will face them on the battlefield. It is critical that U.S. Army systems be survivable on the chemical battlefield through detection and avoidance, and through good design practices. Chemical agents and decontaminants have deleterious effects on many common materials used in modern military systems. Polymers can be softened or embrittled, coatings crazed and metals corroded. It is very costly to test material's vulnerability to various chemical agents. Thus, product to predict effects of materials will not only enhance the design process, it will also save time and money in the testing process.

There is currently a database of material effects, the Chemical Defense Materials Database (CDMD) maintained by the Chemical/Biological Information Analysis Center (CBIAC) that contains an extensive amount of test data. However, this database has not been kept current, and does not provide any predictive capabilities. There is also an extensive amount of test data that is not in any database, but is contained in various reports. Both of these data sources would provide a key starting point for this effort.

This predictive tool will provide key survivability information for the Future Combat System (FCS). FCS is envisioned to be a "system of systems" that may contain both manned and unmanned equipment. Material effects will be most critical to the unmanned components because the weakest link is usually the soldier, and with the soldier removed from the system, materials must be capable of withstanding the agents, and thus become the weak link.

PHASE I:
1. The contractor shall design a software product to predict the effects of an agent or decontaminant on a known material for which there is no agent effects data.
2. The contractor shall devise a plan to incorporate all know material test data into one usable database. Modern technology, e.g. data mining with neural networks, should be considered.
3. The contractor shall demonstrate the predictive capability as described in task 1 for a sample case of materials and agents.

PHASE II:
1. The contractor shall completely populate the database as described in Phase I task 1.
2. The contractor shall fully implement the designed predictive methodology, and incorporate the database as a single tool.

PHASE III: The final software product shall include an attached comprehensive database and have predictive capabilities that will have a broad range of commercial applications. Various industries could use such a tool in various stages of product development to select materials that are resistant to corrosives and severe environments. The base technology of this product would also be useful in generic material type applications, and through incorporation of different databases serve any material industry.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Development of such a capability would greatly reduce test costs and analysis time in evaluating a system. The increased capabilities of systems and the anticipated battlefield environments will have a major impact regarding the use of this tool. The final software product would contain the flexibility to be applied to a broad class of problems.

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Chemical Defense Materials Database (Users Guide), Version 4.0, Chemical Warfare/Chemical and Biological Defense Information Analysis Center (CBIAC), Edgewood Maryland 21040, April 1992.

KEY WORDS: Chemical Agent, decontaminant, NBC Survivability

A01-057 TITLE: Broadband Spectropolarimetric Imagers and Components

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM, Joint Service Wide Area Detection

OBJECTIVE: Design and development of broadband imaging acousto-optic tunable filters, multioctave transducers, and electronically tunable electro-optic infrared retarders.

DESCRIPTION: To meet the sensing requirements for the Future Combat Systems (FCC), the US Army is interested in the development of automated, field-deployable, compact, light-weight, vibration-insensitive, agile, no-moving-parts, remotely-controlled spectropolarimetric imaging systems operating in the spectral region from 2 to 12 micron but preferably from 0.4 to 12 micron for application in target detection and discrimination in day/night and all weather conditions. Spectropolaimetric imagery contains spatial, spectral and polarization signatures of objects in the scene to provide better target detection and identification. The approach used by ARL in the design of such imaging systems is based on using an acousto-optic tunable filter (AOTF) in conjunction with an electronically tunable electro-optic retarder. Development of materials for fabrication of improved AOTF cells that operate over a broad spectral range and electronically tunable electro-optic retarders suitable for such a wavelength agile system are needed. The innovative technologies that need to be developed are crystal growth for AOTF cells operating from 2 to 12 micron but preferably from 0.4 to 12 micron, design of AOTF cells and transducers to facilitate operation over two or more octaves in frequency, and design and fabrication of electronically tunable compact electro-optic retarders over this wavelength range.

PHASE I: Material survey for designing imaging AOTF cells and electronically tunable electro-optic retarders operating from 2 to 12 micron but preferably from 0.4 to 12 micron, design concepts for imaging AOTF cells, electronically tunable electro-optic retarders, and multioctave transducers to be bonded on such cells, and fabrication and delivery of a tunable electro-optic retarder operating over the 2 to 12 micron range but preferably over the 0.4 to 12 micron range.

PHASE II: Delivery of a prototype imaging acousto-optic tunable filter with a matching electronically tunable electro-optic retarder is required. The performance should be demonstrated over the spectral range at least from 2 to 12 micron but preferably from 0.4 to 12 micron. This would require growth of crystal materials, design, fabrication, and characterization of multioctave transducers, and a large aperture AOTF cell.

PHASE III: The components developed under this program can be used in a broad range of civilian and military applications to include medical imaging, robotics, law enforcement, mine and unexploded ordinance detection, aviation, process and quality control, atmospheric monitoring, astronomy, mining, geology, forestry, agriculture, and environmental management, etc.

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KEYWORDS: Acousto-optics, Acousto-optic Tunable Filter, AOTF, Polarizer, Tunable Electro-Optic IR Retarders, Multioctave Transducers.

A01-058 TITLE: Multi-channel Parallel Optical Communication Imager

TECHNOLOGY AREAS: Sensors

Background: Secure and fast information gathering from a network of chip-scale distributed sensors in a wireless environment is an important task for both military and industrial applications. Systems based on radio frequency (RF) communication in current use have several drawbacks. Wireless RF communication can not provide the required level for information protection. Communication with a large network of sensors requires large communication bandwidth that can not be realized for networks of thousands of chip-scale sensors. The use of laser communication can potentially solve these two problems. However, current laser communication systems are limited to communication with only one sensor at a time. The solution to this problem is to employ a detector array (an imager) to receive multiple laser communication beams and separate the communication channels based on position of communication sources in a sensor area.

OBJECTIVES: Develop and demonstrate a free space multi-channel optical communication imager for parallel and secure information gathering from a network of distributed sensors. This entails developing a large scale detector array (an imager) able to (a) receive in parallel multiple laser communication beams, (b) separate the communication channels based on position of communication sources (sensors) in an imager area, (c) provide tracking of the communication sources, and (d) provide on-the-fly information gathering from sensors being seen in an imager area.

PHASE I: Demonstrate feasibility, design and develop an integrated circuit array prototype capable of receiving information from a network of stationary sensors using free space optical communication while simultaneously providing a real time image of area of sensor location.

PHASE II: Demonstrate large scale detector array capable for parallel information gathering from multiple distributed sensors. Refine the design to address a scenario of information gathering from a moving platform. Develop and demonstrate commercial and military applications, and leverage market opportunities.

PHASE III: The integration of imaging and free space communication systems will allow the future deployment of large array of chip-scale sensors with wireless parallel communication capabilities. This will result in wireless, small size, low power, high-performance intelligent systems suitable for a number of military applications. Commercial applications include high-speed free-space communication data transfer between automobiles, helicopters and industrial robots. Techniques developed under this topic are particularly well suited for monitoring applications, such as supervision of industrial robotic assembly lines.

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KEYWORDS: Laser communication, imaging, atmospheric propagation, high speed optical communication, networks and communication

A01-059 TITLE: Bone Conduction Communication Interface

TECHNOLOGY AREAS: Sensors, Human Systems

OBJECTIVE: To develop a head-worn bone conduction communication system to be used by the infantry soldier in a variety of military applications including those requiring mouth or whole-head protection (e.g., whole body armor, respiratory mask, face shield), inconspicuous communication (e.g., surveillance), or communication in high noise environment. The system objective is to provide two-way communication using bone conduction transducers placed on user's head. The system should be compatible with existing army helmets, respiratory masks, helmet mounted displays, face shields, and hearing protection.

DESCRIPTION: Effective two-way speech communication is very difficult in both stealth situations and high noise environments. Such environments may include quasi-stationary noises exceeding 110 dB (A) where speech communication is greatly compromised regardless of the amount of provided hearing protection. Noise canceling microphones and Active Noise Reduction (ANR) earcups provide some means for radio communication but the use of such devices is cumbersome (e.g., close-mouth microphones) and reduces (e.g., earcups or ear-worn devices) auditory situation awareness of the soldier in quiet environments. In addition, the use of respiratory masks or whole-head protection interferes with speech emission through the mouth. A communication system with bone conduction microphones and vibrators located directly on the head may eliminate all these difficulties and be less costly, more comfortable, and an inconspicuous alternative to existing electro-acoustic systems. In addition, such a system facilitates acute auditory situation awareness in quiet and low-noise environments by eliminating ear occlusion caused by earphones and in-the-ear devices. Bone conduction microphones and vibrators are commercially available. This projects calls for the development of a two-way communication system incorporating such transducers and supporting electronic circuitry that permits two-way (duplex) communication without occluding soldier's ears. The basic requirements for such a system are (1) speech intelligibility scores of 91% or better in quiet and in noise levels up to 120 dB (A) when hearing protection is used, (2) two-way communication in quiet and low noise environments without occluding soldier's ears, (3) integration of the system with existing army helmets, head-bands or soft caps worn under helmets, (4) compatibility of the system with hearing protection devices worn under helmets when required, (5) operational capability of the system in environmental conditions specified for existing military audio subsystems (e.g., temperature, humidity, altitude), (6) means for signal level adjustment and hands-free operation, and (7) easy maintenance and low cost of the system.

PHASE I: The objective of Phase I is to perform a system engineering study and to provide a hard-wired working model of the system using commercially available components. The goal of the model is to provide proof of concept and to determine functional capabilities of the future system. Form of packaging and miniaturization of the future system should be addressed in the final report.

PHASE II: The goal of Phase II is to develop and provide a fully functional prototype of the system. Complete documentation is considered a part of the prototype. The performance of the system shall be demonstrated both in quiet and in 120 dB (A) noise with both users wearing MICH helmets and military respiratory masks. The capability of the system to be interfaced with existing military radio systems should be addressed and demonstrated.

PHASE III: The system's potential for commercial applications is enormous. Bone conduction interface is expected to be used by non-military users such as firefighters, security guards, police, and rescue squad members. The use of the system may expand to communication and warning signal systems in noisy industrial facilities. Last, but definitely not least, such systems may be used by virtually all cellular phone users on the move.

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KEYWORDS: bone conduction, two-way communication, infantry helmet

A01-060 TITLE: Integral Starter/Generator Technology for Oil-Free Turbine Engines

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative integral starter/generator technology for Oil-Free foil bearing supported gas turbine systems in a size class suitable for application to Army air and ground vehicles.

DESCRIPTION: This topic seeks innovative integral starter/generator technology for Oil-Free foil air bearing supported gas turbine engine rotors. Recent developments in foil air bearing rotor support technology enable Oil-Free gas turbine systems. However, gas turbine engines typically have oil-lubricated gear driven starter/generator systems. This topic seeks innovative concepts to eliminate the gear driven aspect of the starter/generator systems to realize a completely Oil-Free gas turbine engine. Benefits of Oil-Free gas turbine engine technology include significant weight savings, maintenance cost reductions, efficiency improvements, and increased power density. The proposed research must push integral starter/generator technology beyond the current state-of-the-art level into high-speed and high temperature environment applications relevant to turbine engine and electrical power requirements of Army vehicle systems. The proposed innovation must feature lightweight characteristics for the complete system including power conditioning and controllers. The proposal must identify the critical technology barriers that the proposed research effort must overcome to succeed in developing, applying and commercializing the technology. The proposal must discuss the innovation and technical risk involved in overcoming the critical technology barriers and present a reasonable basis, approach, and timeline for success. The proposal must address anticipated benefits of the technology (such as efficiency, cost, power density, reliability, and maintainability) to the vehicle system. The proposal must include information on potential spin-off military applications and commercial dual-use applications. Research emphasis under this topic must focus on starter/generator technology including integration of the technology within the geometrical constraints of a gas turbine core shaft mounted integral starter/generator system. For purposes of laboratory technology demonstration, minimum continuous steady-state operating parameters are: 30 kW electrical power generation, 60,000 rpm and 500 F. Additionally, the ability to produce a static starting torque of at least 10 ft*lbs. The proposal must demonstrate an understanding of start-up and operating torque characteristics of Oil-Free foil bearing rotor support systems and integral starter/generator systems.

PHASE I: Through experimental testing and/or analytical modeling the Phase I research results must show feasibility of the proposed innovation by demonstrating progress in overcoming the identified critical technology barriers. Prepare a Phase II research plan.

PHASE II: Demonstrate (in a laboratory setting) the integral starter/generator technology at an appropriate scale relevant to an Army vehicle system application and in a relevant operating environment (speeds, temperatures, mechanical and electrical loads).

PHASE III: This technology is applicable to virtually all military and commercial aircraft, helicopter, and UAV gas turbine engines, auxiliary power units, personal mobile power generators, and stationary gas turbine power generators.

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KEYWORDS: Oil-Free, foil bearing, integral starter/generator, gas turbine, auxiliary power unit, power generation, turbo- machinery

A01-061 TITLE: Ultra-Sensitive Raman Detector

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a portable, hand-held, field device capable of detecting and identifying minute, trace amounts of biological material present in liquid, solid, or gaseous (including aerosol-borne) forms using Raman spectroscopy.

DESCRIPTION: This effort will capitalize on recent advances in Raman-based detection to design, fabricate, and test a sensor that provides all the benefits of Raman spectroscopy in the form of a practical military field detector. It must possess the ultra high sensitivity required to overcome the need for intense laser pumping, and have the ability to detect and specifically identify a broad array of bacterial species by their surface antigens at or near the single molecule level in a complex mixture. This portable, hand held device must be low in cost and require little maintenance.

Raman spectroscopy provides valuable information about molecular structure and function through its ability to detect signature spectra of specific chemical entities. However, its utility, particularly in the detection of small number of molecules, has been limited because of the extremely small Raman scattering cross section. Surface-enhanced Raman scattering (SERS) results in significant enhancement of the Raman intensity permitting, for example, the detection and distinction of individual species of bacterial via the detection of their surface antigens. Although SERS results in a significant increase in Raman intensity, Raman sensors using only the SERS effect still typically rely on intense laser pump sources limiting its use has to laboratory-scale experimental devices which are impractical for field use. What is required is increased enhancement of the Raman emission, which would permit small, lightweight pumping sources and increased sensitivity.
A need exists for a portable, hand-held, field device capable of detecting and identifying minute, trace amounts of biological material present in liquid, solid, or gaseous (including aerosol-borne) forms. Such a device should be capable of identification and detection of: specific chemical species at the near-single-molecule level, bacterial surface antigens, different bacterial species, and detection in complex mixtures of unresolved composition. The device should be lightweight with a small operating power requirement and no need for consumable supplies or sample preparation. Recent advances suggest that a device based on Raman spectroscopy has the potential to meet each of these requirements.

PHASE I: Develop the components (sensors, amplifiers, lasers,and powersupply) needed to fabricate compact, portable, Raman-based detectors. Investigate either contact or remote sensor strategies. Confirm the technology concepts with appropriate experimental laboratory demonstrations on biologically relevant materials.

PHASE II: Optimize the various sensor parameters to achieve reliable, ultra-sensitive detection of molecular species at the single-molecule level present in the sample both individually and as a mixture. Conduct trial studies to detect and identify selected molecular species of interest either in the contact or remote detection mode.

PHASE III: Further optimize sensor parameters under production conditions. Identify spectral templates permitting rapid identification of a variety of molecular species. Conduct trials with prototype sensor illustrating technology features and limits. In addition to military use, the device will prove valuable by civilian defense agencies involved in counter-bioterrorism. Other applications include detection of bacterial contamination (salmonella, E. coli, etc) in meat packing and food processing plants, and in hospitals and other health care environments by public health and medical diagnostic workers.

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KEY WORDS: biological or bacterial warfare agents, bacterial detection, bacterial contamination, Raman spectroscopy

A01-062 TITLE: Material Technology for Thermal Management of Gun Barrels

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Mortars

OBJECTIVE: The objective is to utilize materials having thermal conductivities that allow for a more efficient way of managing the heat transfer through the thickness of a thin-walled cannon such as a mortar barrel. It is desired to sufficiently reduce the maximum soak temperature of a barrel so as to allow the use of lightweight material overwraps on a thin-walled steel bore liner that is pressurized to 16,000 psi.

DESCRIPTION: At present, the U.S. Army uses thin-walled steel barrels for mortar applications. It is desired to reduce the weight of these systems by incorporating lightweight materials that typically have a greatly reduced operational temperature range. Due to concerns with the wear and erosion resulting from propellant combustion gases, it is envisioned that any lightweight barrel will likely have a steel bore liner that is overwrapped or sheathed with a lighter weight material. Mortars have rates of fire that result in substantial heat being introduced to the barrel walls. Currently, U.S. mortar barrel designs, for both 60- and 81-mm calibers, incorporate annular cooling fins to assist in the dissipation of heat from a thin-walled barrel via convection.

There are two competing approaches that may be examined in attempt to reduce the total heat stored by a lightweight overwrap of a steel cylinder such as a gun barrel. The approach chosen will dictate the class of materials that are examined in this investigation. One approach would be to evaluate highly conductive materials to determine if sufficient heat can be transported to the outside wall surface to minimize the through-thickness heating. Conversely, an opposite approach may be examined that incorporates insulator materials or coatings that act as thermal barriers to keep heat away from an overwrap. In this case, thermal build-up in the steel liner should be quantified.

Regardless of approach, it is desired that temperatures in the overwrap should not exceed 350F when subjected to an internal heat source that is capable of heating the interior cylinder wall to 800F. For analysis purposes, the cylinder wall thickness of the steel shall be at least 0.1 in (2.5 mm) and not exceed 0.4 in (10 mm) in thickness. The incorporation of additional materials to improve heat removal or act as a barrier/insulator should be limited in use so as not to comprise more than 5% of the mass of the steel cylinder on a per unit length basis.

PHASE I: Investigate means of deterring the accumulation of heat in thin-walled mortar designs subjected to sustained firing rates. These firing rates are assumed to generate interior wall temperatures of 800F in a hollow, thin-walled, steel cylinder. Depending on the approach adopted, assessments and material definition of thermal barriers and/or cooling augmentation schemes should be made to determine their effectiveness in either deterring heat transport to an outside overwrap having the conductivity of fiber-reinforced graphite epoxy or transporting sufficient heat through the overwrap to the external, air-cooled surface. Success will be based on the ability of the material and design approach to insure that the overwrap interface surface temperature does not exceed 350F when subjected to the assumed internal heat rate. The design approach should be modeled and analyzed to insure the design not only meets all thermal goals, but can also withstand internal pressurization of 16,000 psi. The design approach should be integral to the overwrapped steel cylinder and not include exterior fans, blowers, or pumps to move fluid as a means of cooling.

PHASE II: A design approach should be downselected and a small-scale prototype built and tested to demonstrate the response of the concept. The selected technology should then be demonstrated when subjected to an internal heat source that imparts a temperature of 800F on the internal wall surface.

PHASE III: Technology has application to all calibers of cannons for mortars, howitzers, and tank cannons.

DUAL USE COMMERCIALIZATION: The utility of the technology depends on the technology approach adopted. If thermal barrier materials are pursued the technology has transfer potential as a means for reducing exterior temperatures of equipment and components that require handling. They also could function as a superior insulator and be used to facilitate the transfer of fluids with very little thermal loss. Applications would include use with home heating systems, steam turbines, and refrigeration systems.

If an augmented cooling approach were adopted, the technology would have application to all industries that have the need for improved heat exchangers. It is envisioned that the power industry would have particular interest in this technology. It would also be applicable to generators, engines, motors, and other machinery that generate significant heat while operating, and require active cooling via oils and fans.

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KEYWORDS: mortar applications, lightweight materials, lightweight barrel, steel bore liner, cooling, heat exchangers

A01-063 TITLE: Low Cost Obstacle Avoidance System For Very Miniature Rotorcraft

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: To resolve research issues prerequisite to developing autonomous miniature rotorcraft for urban reconnaissance.

DESCRIPTION: Various approaches for navigating a small, unmanned aerial vehicle (UAV) around urban structures to an assigned reconnaissance coordinate have been postulated. These include (a) conventional remote piloting, (b) automated route planning within a detailed terrain data base, and others. An approach that is much less demanding of operator attention or of pre-collected information is needed. Ideally, the UAV should require only the target point and should be able to use obstacle avoidance techniques to overcome the hazards of mapped and unmapped structures alike. Robust capability would entail very tight maneuver and perhaps many path corrections within a few seconds, similar to the flight of a bat. Control systems that could support such an ideal do not exist. Therefore analyses of flight control concepts that could feature very high responsiveness to proximity sensor data should be carried out. These should be followed by simulations and/or experiments to support the analytical results, maintaining awareness of the constraints imposed by this class of Army missions.

PHASE I: Outline the accumulating of data by sensors of various types on general obstacles that are entering the flight path at an arbitrary azimuth. Describe obstacle avoidance strategies and maneuvers available to a rotary-wing aircraft. Include opposite-extreme approaches such as (1) earliest maneuver using minimum information, and (2) most precise maneuver using maximum information, and outline the limitations of these extremes. Seek intelligent intermediate strategies, perhaps employing fuzzy logic approaches or equation blending. Formulate these as flight control algorithms or rule sets. As a side issue, characterize the sorting and computing pros and cons of overwriting old data.

PHASE II: Select two or more promising obstacle avoidance algorithms or rule sets and program these into flight control research simulations. In behalf of timeline fidelity and to ensure credibility of the results, reference current or near-future-projected parameters for miniature hardware items. These would include candidate onboard sensors and processors, and also the upcoming family of DARPA microUAVs. A substantial number of cases should be run, with the goal of determining the most robust control solutions. If rate of progress permits, plan and/or initiate flight demonstration on appropriately modified government or commercial miniature rotorcraft, retaining a manual override control mode.

PHASE III: The above-described Army application is seen as key to efficient, low-casualty urban takedown, for it would afford observation at upper-floor windows from distances of several city blocks. There is an analogous police application, namely riot control. A general business and emergency medical application would be expedient delivery of high-priority packages through a means unimpeded by urban traffic, or by natural obstacles in a countryside environment.

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KEY WORDS: obstacle avoidance, proximity sensors, collision, autonomous, flight, UAV, urban, MOUT, control, unmanned, robotics, algorithms, maneuver, rules.

A01-064 TITLE: Control of Multiple Unmanned Systems

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Program Manager Future Combat Systems

OBJECTIVE: Integrate past research and conduct new research studies to create a tool for understanding the relationship between operator workload and system parameters that ultimately affect how many unmanned systems a single soldier or group of soldiers can control.

DESCRIPTION: The Future Combat Systems (FCS) program will emphasize the use of unmanned systems and accelerate the development of semi-autonomous systems. These systems will vary from micro-UAVs (Unmanned Aerial vehicles) to 20-ton direct and indirect fire ground platforms. Techniques for controlling multiple unmanned systems will be key to the success of FCS. Very little research exists upon which to base decisions concerning the number of systems an individual soldier or group of soldiers can control; particularly given the scope of capabilities of these systems. Previous control approaches were equipment-platform centered and operator's workload was represented in simplistic terms in a piecemeal fashion (whatever a particular program needed at the time). The level of autonomy of future systems will be affected by many factors such as terrain, mechanical failure, weather, type of mission profile, and accuracy of target detection and identification. These factors affect the frequency and nature of the soldier's interaction with unmanned systems. Typically, the goal for many previous platforms was to automate everything, leaving the operator with nothing to do. This level of autonomy will be difficult to achieve in FCS. In addition, cognitive models exist that provide more realistic means for addressing operator workload than in past approaches. The goal for this research is to systematically integrate previous research on control taxonomies and operator workload into an architecture that can form the basis of a trade-off analysis software tool. The tool will provide the means for establishing the boundaries on the relevant factors through sensitivity analyses that will provide insight to understanding and investigating the relationship between system parameters and operator workload. Research studies will be required to augment the tool where current data is inadequate and to subsequently demonstrate the validity of the tool. Development of the tool will require research investigations to address the single operator-single system through multiple operator-multiple systems cases. Ideally, the tool will provide insight to the implications for a brigade-sized element for estimates at higher levels of modeling that support the Army's Simulation Based Acquisition initiatives. The tool will identify the feasible ranges of the factors and their relative impact on operator workload which, in turn, will identify critical areas for future research and help guide future system development.

PHASE I: Review existing literature concerning robotics, semi-autonomous, and teleoperated systems as well as current and emerging models of operator cognitive workload. Determine range of factors that could impact unmanned military operations. Identify relevant cognitive models. Formulate an approach for developing the tool, and identify potential research studies required for Phase II.

PHASE II: Conduct research studies to fill data voids, develop model and validate output on a representative set of unmanned systems assuming anywhere from one to 6 operators controlling up to the theoretical maximum of systems for at least one representative mission.

PHASE III: The commercial industry has focused on production line uses of robotics with very little emphasis on control of multiple systems by single operators or groups of operators beyond production line types of operation. The SBIR will help commercial industries establish a broader scope of control of unmanned systems by operators for a far broader group of applications than previously considered.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The Army will benefit from reduction in number of soldiers required to man the future force and maximize the use of new technologies for limiting exposure of soldiers to combat on the future battlefield.

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KEYWORDS: Robotics, Unmanned Systems, Teleoperation

A01-065 TITLE: <u>Ultra High Resolution/High Speed Visible Imagers</u>

TECHNOLOGY AREAS: Sensors

OBJECTIVE: New or novel techniques and/or technologies are solicited for the development of advanced ultra high speed and high-resolution visible imager systems. The goal of such systems is to provide resolutions on the order of 12+mega pixel at full frame rates up to 1000 frames per second. The objective will be to demonstrate the feasibility of developing a 12+megapixel, 200-1000 frames per second, 35mm 10-12 bit pixel format visible imaging sensor. This effort will consider suitable architectures for simultaneous frame shuttering, minimized blooming, low fixed pattern noise, low light capability, horizontal and vertical binning for higher frame rates, and very low power consumption. The required high pixel bandwidth will necessitate consideration of lossless precompression techniques for use with a companion compression Application Specific Integrated Circuit (ASIC) in order to realize at least a 15 to 1 lossless compression stream. Realization of these goals is anticipated to require the use of materials with high quantum efficiencies in the visible (400 to 800 nanometer (nm)) region, and implementation of Focal Plane Array architectures that are not charge transfer devices.

Current state-of-the-art visible camera systems can provide either the required resolutions or frame rates, but not both simultaneously. To realize the objective of this effort, it is anticipated that a deviation from traditional visible imager design architectures will be required.

DESCRIPTION: Significant improvements in the digital collection of visible imagery are required to replace 35 millimeter film and to address deficiencies encountered in the Test and Evaluation (T&E) of military systems where it is often necessary to collect visible imagery during the conduct of weapons testing. An example of such is a missile launch or engagement.

Visible imagery is crucial to T&E of the weapons systems performance. The speed at which events of interest occur and the lack of suitable visible imager techologies, have forced T&E ranges to compromise resolution for speed or continue the use of film contributing to environmental concerns and time delays in getting visible imaging products to the customer. For example, within the Army at White Sands Missile Range, successful development of high performance imagers (Ref 1.0) has been successfully executed to the limits of the available technology and has provided visible camera systems that begin to approach the needs of T&E ranges.

Beyond T&E ranges, a review of the current state of the art visible image collection indicates that despite current and past industry and goverment efforts, the combination of high resolution and high frame rates for visible imagers has not yet been achieved. Limitations in the performance of current state-of-the-art visible camera systems may be attributed to physical limitations in the architectures employed in Focal Plane Arrays (FPA).

The investigators shall identify, research and develop such architectures. The technology developed shall be suitable for use in the visible band (i.e. nominally the 400 to 800 nm wavelength). Design goals are to simultaneously provide pixel densities on the order of 4096 x 3072 at frame rates on the order of 1000 frames per second and with 10 to 12 bit digitization. Monolithic sensors are preferred over tiled. In addition to the resolution and speed, other specifications, such as high quantum efficiency, good dynamic range, sensitivity, noise, etc. are to be comparable or better than current state-of-the-art devices while minimizing blooming and smearing effects.

PHASE I: The investigator shall conduct the necessary analysis and research to develop the technology for the design and fabrication of visible sensors and associated cameras that can simultaneously provide high speeds and high resolutions as described above. The analysis and research shall provide the basis for a full-scale sensor prototype development in Phase II. Technical risk is to be minimized by leveraging.

PHASE II: The investigator shall proceed with prototype development and demonstration of the technology proposed in Phase I. The full-scale sensor development shall ensure that other issues beyond the sensor are addressed. These issues include, but are not limited to, lossless compression, high-speed data interface, data timing, etc.

PHASE III: DUAL USE APPLICATIONS include both military and commercialization. There is a tremendous world wide application for significantly improved visible imagers. Improved imagers will find wide spread use in Hollywood, medical, law enforcement, industrial inspection systems, search and rescue, miltary, and aviation.

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High Frame Rate IR and Visible Cameras for Test Range Instrumentation, SPIE July 1995, Dr. Joseph Ambrose and Brad King (White Sands Missile Range) and John Tower et. al Sarnoff Laboratories.

KEYWORDS: Visible, imagers, cameras, sensors, FPA

A01-066 TITLE: Analytical Point Field Detector

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: A clever and creative approach is solicited for development of a small low-cost point detector that can detect a wide range of chemicals at low concentrations (~0.1 ppm or less).

DESCRIPTION: Test and evaluation of standoff chemical detectors requires multidimensional mapping for chemical warfare (CW) simulant field releases[1]. Mappings used to evaluate performance of standoff detectors include cloud dimensions, tracking, and concentration profile. This is achieved by merging data from referee standoff detectors, meteorological, and point detectors. To best produce the desired cloud characterization, hundreds of field-ready point detectors will be needed with data output suited for remote communication. Unfortunately, no point detector can meet our needs.

Current government-off-the-self (GOTS) and commercial-off-the-self (COTS) detectors can detect some of current field simlants, but not all at the necessary concentrations [2]. Simulants include spectral simulants that mimic the infrared spectra of CW agents and physical simulants that mimic properties such as vapor pressure. Primary field simulants used are tri-ethyl phosphate, p-xylene, sulfur hexafluoride, methyl salyliciate, and acetic acid. One challenge will be to build a detector that can detect physically dissimilar compounds, which have proven difficult for current Ion Mobility, Photo-Ionization, and Infrared point detectors.

Investigators must propose a detector that can best meet the following requirements:
* detect and quantify the desired simulants at concentrations of 0.1 ppm or less,
* cost under $15 K per unit,
* capable of field use,
* data output conducive for remote use,
* and quick detection and clear times.

Outside the T & E community, three customers would have immediate use for such a detector. First, the military would benefit because detectors that can detect CW simulant could also detect agent, and could conceivably be part of a matrixed detection suite at fixed base. Second, the first responder community would benefit for the same reasons as the military - a low cost CW detector. The final customer would be agencies and academia that perform field monitoring for environmental (or other) types of monitoring.

PHASE I: Investigator needs conduct necessary research to develop a detector design approach that will meet the above requirements. This includes selecting the best detection technology, instrument design, and data processing. Planning at this stage will serve as the blue print for a full-scale detector prototype development in Phase II.

PHASE II: The development approach from Phase I will be implemented to build a functional prototype.

PHASE III: DUAL USE APPLICATIONS include both military and commercialization. The military could use this detector for CW agents, as could first responders. Other agencies that have interest in environmental monitoring (EPA or universities) would also benefit by having a sensitive, affordable, field instrument.

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KEWORDS: Chemical warfare, tracking, detection, point detector

A01-067 TITLE: <u>Probabilistic Design Tool for Analysis of Mistuned Bladed Disks</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PM, Utility Helicopters

OBJECTIVE: Develop innovative methodologies and models for accurate probabilistic HCF life prediction of turboshaft engine components.

DESCRIPTION: Under the DoD/NASA/Industry/Academia sponsored HCF Science and Technology program there is a strong push towards the use of probabilistic methods to improve the accuracy of HCF life prediction mainly as applied to the Fan/Jet class of engines. Little has been done for direct application to the turboshaft/turboprop engine class to date, which has specific configuration differences such as centrifugal compressors. Various probabilistic methodologies are being investigated for application to several different aspects of HCF or relative to different HCF technologies. Examples of various probabilistic approaches are monte carlo simulation, second-order reliability method, advanced mean value, and response surface method. The various approaches may work well for a specific HCF problem, but do not generally work for all HCF problems. Particular attention must be taken to validate the accuracy of a given approach applied to a given type of problem. This topic is looking for any such probabilistic methodology or model development effort for application to components of Army turboshaft engines in the 3,000 to 15,000 horsepower class. The following two specific examples of HCF probabilistic modeling areas of interest to the Army are provided for reference: 1) for application to mistuned integrally bladed compressor disks (blisks) and impellers or 2) for components that have been modified by advanced surface enhancement processes.

1) Today, a large majority of compressor rotors in turboshaft engines are designed and fabricated as integrally bladed disks (or blisks) in which the blades and disk are one piece. These blisks are inherently more prone to High Cycle Fatigue (HCF) due to their having less damping capability than separate blade/disk designs. Also, current and future blade geometries are becoming more 3-dimensional and complex (i.e. blade sweep) for increased performance which makes it even more difficult to achieve HCF life. Also, compressor blades are only nominally identical; differences in manufacture, differences in wear during use, and similar uncontrollable factors lead to random variation between blades. The nominally identical angular sectors in fact vary randomly in geometry and material properties; these random variations are generically called `mistuning.' Although the discrepancies may be small, the effects of mistuning can be unexpectedly large. Whereas the normal modes in an exactly periodic structure have a trigonometric, hence smooth, variation with angular sector, the normal modes in a mistuned structure can exhibit "mode localization" in which a normal mode has very large amplitudes over a small number of adjacent blades. Localization can cause, among other undesirable consequences, greatly reduced fatigue life of a mistuned bladed disk assembly compared to the fatigue life of an ideal, exactly periodic structure. The prediction of mistuning effects in bladed disk assemblies is consequently of fundamental importance in achieving a robust HCF resistant design. The development and validation of an advanced and economical tool for the probabilistic assessment of random mistuning effects in small engines is key to effectively predicting mistuning effects upfront in the design process, thereby producing more robust, HCF free high performance engine components.

2) Several approaches are being pursued to enhance HCF life and performance of components under the HCF National Program. One promising approach is to use an advanced surface enhancement process (SEP) such as laser shock peening (LSP), gravity peening, or Low Plasticity Burnishing (LPB). Laboratory tests have shown that SEPs can enhance HCF life of test coupons by more than a factor of ten. Conversely, for a given life requirement, SEPs can be used in substantially increasing power to weight ratio. Some SEPs are more economical than others but may have limitations such as the inability to handle certain component geometries. Significant performance, affordability and reliability benefits can be achieved if the effectiveness of SEPs can be quantified for the materials, configurations and engine environment conditions relevant to advanced turboshaft engines. Quantification can be achieved by developing, validating and using innovative modeling techniques and design methodologies for predicting the redistribution of residual stresses induced by SEPs under thermal and probabilistic HCF loading conditions. The developed models and methodologies will provide a design system that identifies the appropriate SEP parameters to be applied to a given component for optimal HCF performance without the need for labor intensive processing iterations to achieve this optimal HCF life. These models would also enable use of multiple SEPs on a component as well as component specific selection of SEPs to maximize benefits while minimizing cost.

The successful development of such HCF models and methodologies will consequently lead to a significant reduction in development and operating and support (O&S) / logistics costs by reducing the occurrence of HCF failures during engine development testing or during use in the field. It will also enable the use of more aerodynamically advanced blade designs, which will ultimately lead to increased rotorcraft range or payload and potential fuel savings. The resulting increased range/payload and reduced logistics footprint/cost is in direct support of the Chief of Staff of the Army's vision for the objective force.

PHASE I: Develop conceptual design of probabilistic tool or methodology and establish feasibility of the tool for use in modeling HCF in turboshaft engine components.

PHASE II: Further develop the probabilistic model into a robust prototype tool and validate the prototype tool on a representative turboshaft/turboprop engine component which has sufficient test data for comparison/validation purposes.

PHASE III: Generalize the methodology and software developed in Phase II to a broader class of compressor rotor configurations/material systems/operating conditions/etc. This generalization would significantly broaden the applicability of the given methodology to other military as well as commercial applications.

DUAL USE APPLICATIONS: The methodology and software would be readily marketable to commercial and military aircraft engine manufacturers. Additionally, the product will be marketable to automotive, ground vehicles, and industrial gas turbine engine manufacturers. The resulting technology will facilitate achievement of engine components having robust design lives relative to high cycle fatigue, thereby reducing development and O&S costs of both military aircraft and tank engines and commercial aircraft engines. It will also reduce the risk of having catastrophic in-flight, HCF related engine failures for both military and commercial aircraft.

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KEYWORDS: Gas Turbine Engine, High Cycle Fatigue, Life Prediction, Probabilistic models, blade mistuning, surface enhancement processes.

A01-068 TITLE: Helicopter Rotor and Tail Surface Aerodynamic Interaction

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO, Aviation

OBJECTIVE: Develop technology and practical solutions to eliminate adverse aerodynamic interactions between helicopter rotor systems and tail surfaces and anti-torque control systems.

DESCRIPTION: Rotorcraft engineering development and operational experience are seriously impacted by adverse aerodynamic interactions that arise from helicopter main rotor, rotor hub, rotor pylon and engine exhaust flow-fields. Aerodynamic interactions phenomena involve the helicopter horizontal and vertical tail surfaces, the anti-torque, directional control, and longitudinal trim systems of the aircraft. These aerodynamic interactions are involve complex flow-field phenomena (e.g., Ref 1) that are not well understood, cannot be well predicted, and result in major uncertainties, especially in the design of new rotorcraft. The inability to accurately model and predict these characteristics results in major deficiencies including vibration, buffet, poor handling qualities, and structural and fatigue problems, Ref. 2. When discovered during flight testing, these problems generate significant delay in testing and major cost increases as ad hoc solutions and fixes are developed. The lack of adequate design methods requires the fixes to the original problems to be developed on a cut and try basis as well. This topic will involve the development of new technology to understand, analyze, and predict these complex phenomena as well as develop the candidate rotor pylon, hub, and tail surface configuration concepts that will mitigate the problems for either specific or generic helicopter configuration types.

PHASE I: Analytical and experimental investigations of promising analysis methodology and concepts will be explored and identified. This may include experimental or analytical studies. Analytical investigations using specialized fluid mechanics analyses, computation fluid dynamics (CFD) methods, or comprehensive rotorcraft codes. Experimental flow field studies may include testing of generic component shapes or specific production rotorcraft design configurations. Unique configuration concepts to attack the adverse effects of flow-field interactions will be identified, possibly including re-evaluation of concepts and approaches investigated or developed in the past.

PHASE II: Promising methodologies and concepts will be thoroughly explored and refined to the point of practical application. Analytical and computational methods will be refined for use in design applications including validation with available experimental data. Promising configuration concepts will be refined and tested in realistic environments, including experiments with full rotor tail interaction experiments or where appropriate, in full-scale flight test applications.

PHASE III: Commercialization potential will involve development of design methodology that can be produced for the helicopter industry and for the government. Advanced configuration concepts may be developed that can be licensed to the major helicopter manufacturers.

DUAL-USE APPLICATIONS: Design methodology and configuration concepts to eliminate adverse aerodynamic interactions will have significant potential for application to both civil and military rotorcraft. The potential for significant advancement of rotorcraft effectiveness and cost reductions will advance the spread of rotorcraft mission capability for both civil and military applications.

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KEYWORDS: Aerodynamic interactions phenomena, helicopter

A01-069 TITLE: Standardized Video Compression/Decompression System for Use in Transmitting Sensor Data Over Rotorcraft Tactical Radios

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO, Aviation

OBJECTIVE: The objective of this program is to develop and demonstrate the capability of sending and receiving EIA-170 video and 875 line, EIA-343A video over current Army rotorcraft tactical radios using emerging video compression techniques.

DESCRIPTION: There is a great need to distribute sensor data off-platform to be utilized in teaming operations between unmanned aerial vehicles (UAVs), rotorcraft, aircraft and ground personnel to improve situational awareness, effectiveness, and survivability. A major cost/integration factor to implement transmitting large volumes of data is the acquisition of new datalink equipment to transmit this data due to the low bandwidth of the current tactical radios. One solution could be to compress the data enough so it could be transmitted across current tactical radios. This must be done in real time and such that the video quality is not degraded. It is desirable that a standard video compression/decompression technique be adopted to reduce the cost of acquiring several different proprietary algorithms and hardware for video compression. The video compression/decompression system will be able to compress/decompress (without significant loss of quality) analog video consisting of 525 lines/frame (conforming to EIA-170 and SMPTE 170M) and analog video consisting of 875 line, 4:3 aspect ratio, interlaced with 60 fields/sec (30 frames/sec) (conforming to EIA-343A and STANAG 3350) and transmit it over current Army rotorcraft tactical radios. The system shall determine what tactical radio is in use and configure itself to obtain the maximum performance for each type of tactical radio. The transmission range will be dependant on which tactical radio is being utilized. The video compression/decompression system must easily integrate into avionics communication and sensor systems. It is preferred that the architecture of the system be compliant with the Rotorcraft Open Systems Avionics (ROSA) Rotorcraft Technical Architecture (RTA). This topic focuses on developing a standard compression scheme to allow the transmission of video utilizing the current tactical radios already installed on rotorcraft. A major consideration is not changing the current communication systems. This would allow a standardized and economical integration into a variety of platforms.

PHASE I: Capabilities of existing/emerging Army rotorcraft tactical radios to meet this requirement shall be evaluated. The evaluation shall include consideration of technical issues (bandwidth of available satellites and radios, frequency restrictions, transmission ranges, frame rates, video compression techniques, weight, power, transmit/receive aircraft integration, relay aircraft/UAV integration, data security, sensitivity to jamming, etc.) and non-technical factors (cost, maturity, availability etc.). Determine the system that could be used as a standardized video compression/decompression system for Army rotorcraft. The system shall be able to configure itself to obtain maximum performance for each type of tactical radio. Develop overall system design that includes video compression technology, hardware requirements, and interface requirements. The components of this system should be compact and light enough to be utilized onboard UAVs, mobile ground personnel, rotorcraft and other weapon systems.

PHASE II: Develop and demonstrate a prototype system in a realistic environment (transmission of 875 line, EIA-343A video over current Army rotorcraft (attack/recon/special operations) tactical radios to be received by a ground station. Conduct testing to prove feasibility over extended operating conditions.

PHASE III: Dual Use Applications: The resulting miniaturized compression/decompression system capable of providing video information that could be transmitted across low bandwidth communication systems would find acceptance in video phones, video security, and broadcasting markets.

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KEYWORDS: Data compression, sensors, video, low bandwidth

A01-070 TITLE: Generation of Consistent Rotorcraft Dynamics Models for Life Cycle Simulation Support

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation Simulation Office

OBJECTIVE: Establish the capability to generate and validate selective fidelity simulation models of rotorcraft dynamics from a primary comprehensive modeling tool to support all applications in the development and operational cycle with consistent, traceable dynamics models that are customized to the application.

DESCRIPTION: The increased emphasis on modeling and simulation in support of all phases of design, testing and operational deployment of new and modified rotorcraft has the promise of reduced cost and improved designs. Each stage of the development cycle typically requires customized simulation models. The development cycle begins with the use of logistics models to define mission requirements. It then proceeds to conceptual design where performance models are used to establish the basic vehicle type, size and power requirements to achieve the mission requirements (Ref. 1). Preliminary design follows (Ref. 2), where handling qualities models are used to appraise the stability and maneuverability. In the detailed design phase (Ref. 3), each discipline typically uses a dedicated specialized simulation model for design and analysis of propulsion systems, control systems, aerodynamics, and structures. Test and evaluation requires high fidelity multidisciplinary models to address the interaction between aircraft systems in planning and analyzing experimental tests. Simulation based acquisition uses cost models combined with performance models to assess the cost tradeoffs over the life cycle of the vehicle. Training requires a range of real time models with varying sophistication to support collective training, procedures training and operational flight training applications. The diverse simulation types required to most effectively support each phase of the development and operational cycle necessitate configuration management to assure consistency of results across the development spectrum. The ability to use a tested, physically based, comprehensive modeling tool to generate dynamics models with selective fidelity, customized to each simulation application involved in development and operation, would provide the required level of commonality and traceability throughout the vehicle life cycle. This topic addresses the use of tested, comprehensive rotorcraft simulations as a primary model for obtaining specialized dynamics models for each application involved in the vehicle's life cycle.

PHASE I: Under Phase I the use of a comprehensive modeling tool to generate the performance models required for conceptual design should be demonstrated along with the ability to test the performance predictions of the conceptual design models on the comprehensive model.

PHASE II: Under Phase II the use of a comprehensive modeling tool to generate selective fidelity dynamics models to support handling qualities analysis, detailed design, cost analysis, test and evaluation, and training should be demonstrated. A rotorcraft of specific interest to the Army should be modeled for the demonstration. Potential Accreditation standards for models supporting each discipline will also be evaluated.

PHASE III: The ability to generate and validate selective fidelity models for a range of applications from a single comprehensive model can extend the value of simulations developed for Military applications to the entertainment industry. This in turn can result in Military utilization of special effects technology developed for the entertainment industry. The idea of deriving customized simulation models from a comprehensive primary model can also be applied to commercial aviation and the automotive industry.

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1) Preston, J. and Peyran, R., "Linking a Solid-Modeling Capability with a Conceptual Rotorcraft Sizing Code", American Helicopter Society Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 2000.
2) Choi, K, He, C.J. and Du Val, R.W., "Helicopter Rotor Disk and Blade Element Comparisons", American Helicopter Society 52nd Annual Forum, Washington D.C., June, 1996.
3) Ormiston, R.A., Ruzicka, G.C., Jung, Y. and Saberi, H., "Comprehensive Aeromechanics Analysis of Complex Rotorcraft Using 2GCHAS," Proceedings of the Aeromechanics Specialists Conference on Aerodynamics, Acoustics, and Dynamics, San Francisco, CA, Jan., 1994

KEYWORDS: rotorcraft dynamics models, life cycle simulation support, rotorcraft, propulsion systems, control systems, aerodynamics, structures

A01-071 TITLE: Passive Terrain Following

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Technology Applications Program Office (TAPO)

OBJECTIVE: The objective of this program is to demonstrate the feasibility of developing a passive terrain following and terrain avoidance (TF/TA) system for low flying helicopters. The passive system is based on combining aircraft real time GPS information received with an onboard digital data base of terrain features available through Digital Terrain and Elevation Data (DTED) and presenting the synergized information to the flight crew.

DESCRIPTION: To perform its missions United States Special Operations Command (USSOCOM) helicopters are required to fly low altitude contour flight to reduce detectability and exposure times. To safely fly at these altitudes the USSOCOM MH-60K and MH-47E use the AN/APQ-174 multi mode radar (MMR) for terrain following and terrain avoidance and use a Doppler system for navigation. Testing has uncovered several deficiencies in these Special Operations Force (SOF) rotary wing systems. The first of the deficiencies is the ability of passive threat detection systems to exploit emissions from the MMR and the Doppler navigation radar. Another deficiency is that these systems are subject to jamming since it utilizes radar emissions for navigation information. And lastly, because of the operating frequency of the MMR, the radar can provide erroneous information to the pilot by missing obstacles with low target returns, whether because of material properties of the obstacle or its shape. These recently identified deficiencies coupled with the greater than 300-lb. weight penalty with the MMR highlights the need for an alternate, passive system for providing the TF/TA information.

The advances in computer processing speeds, data storage capabilities, and miniaturization of computers have significantly advanced the utilization of GPS for navigation. In addition, the global DTED and Digital Features Analysis Data (DFAD) databases are continually being updated with more resolution. As an example, a recent Shuttle mission collected ISAR imagery to establish a worldwide Level II DTED database. The advancements in these two technology areas has reached the point where it is theoretically possible to fly low level contour flight with a coupled digital map and GPS navigation systems.

PHASE I: System Study
This phase of the program will consist of a study that evaluates the technical feasibility of a using a passive TF/TA system based on GPS position and a DTED/DFAD data base for low altitude contour flight missions. The feasibility study will evaluate the ability to present the terrain information to the pilot and the reliability of the system for various USSOCOM missions. The study will assess the computational and data storage requirements for different combinations of aircraft speed, altitude, and terrain variations, for the three different DTED data levels (I - 100 m altitude post, II - 10 m altitude post, III - 1m altitude post). The study will result in a conceptual design, predicting expected system performance, system accuracies as well as the identification of limiting parameters to integrating a system like this into SOF aircraft.

PHASE II: Demonstration Flight Testing
This phase of the program will be expanded to the design, fabrication, and flight-testing of a passive navigation system for a limited concept demonstration. Based on the information developed in Phase I, a strap down system will be developed to be integrated on a USSOCOM rotary wing aircraft. Analysis will be performed to substantiate system capability to provide contour flight navigation cues. This analysis shall include sensitivity to calibration errors, drift, dropout, basic system errors, etc. The system will then be integrated in a Government furnished aircraft and flight-tested to evaluate system performance. Hardware integration approach consists of integrating the system and instrumentation on a strap down pallet in the back of the aircraft. The displays shall be provided to the pilot in the cockpit and to the engineer in the back of the aircraft from the hardware package

PHASE III: Implementation
The PM for Army Special Operations Forces (SOF) aviation, TAPO, would implement the successful results of this program in the current fleet of MH-60K's and MH-47E's which have the multi mode radars (MMR) installed. The implemented program would have successfully addressed the need to balance flight safety, air speed, terrain clearance, hazard avoidance (wires, towers, etc) and digital map accuracy. A successful program would save approximately 300 lbs due to elimination of the MMR and make missions more covet due to the elimination of electrical emissions. The potential exists for application to other USSOCOM aircraft (CV-22, AC-130 and MC-130).

DUAL USE APPLICATION:
The technology has application to civil and commerical aircraft. The wide spread use GPS and moving map displays made the electronic integration of the two systems a natural next step. It would add a third dimension to navigation programs and ensure proper ground clearance is maintained with appropriate warnings issued when minimum clearance is violated. This would enhance safety especially in mountainous terrain.

RERERENCES: none

ACRONYMS: DFAD – Digital Features Analysis Data, DTED - Digital Terrain and Elevation Data, GPS - Global Positioning System, SOF – Special Operations Force, TF/TA - Terrain Following/Terrain Avoidance,

KEY WORDS: Digital map, GPS, Aircraft, Navigation

A01-072 TITLE: Reliable Actuators for Micro Unmanned Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop of reliable, lightweight, high-bandwidth, miniature actuators suitable for use on micro Unmanned Aerial Vehicles (UAVs).

DESCRIPTION: In recent years there has been a dramatic increase in the number of UAV development programs. The US Army along with the other branches of the military has recognized the capability of UAVs in performing surveillance and payload transportation. These vehicles working with ground troops or deployed from rotorcraft have an amazing potential for improved mission success. Recent advances in materials and electronics have facilitated the development of a class of vehicles called micro UAVs. These vehicles are typically under a foot in size and are capable of navigating constrained areas and taking and relaying video images. While advances have been made in some areas of miniature electronics, the area of "reliable micro actuators" has been largely overlooked. Since as vehicle size decreases the frequency of the vehicle dynamics increases, when a micro-air-vehicle's size shrinks to less than a foot, designs are forced into a corner that requires lighter actuators with higher bandwidths. So far, however, micro UAV developers have had to rely on hobby-quality actuators that are typically too big, too heavy, too slow, inefficient, and unreliable. None of the micro air vehicle technology programs, such as the Defense Advanced Research Projects Agency (DARPA) Micro Air Vehicles (MAV) program, have focused on this technology. Instead, most miniaturization efforts to date have concentrated on such things as inertial measurement packages, powerplants, and sensors. While increased actuator bandwidth can be achieved by overdriving the actuators with higher voltage this approach drastically reduces the life of the actuator. Research areas such as robotics and computer disk drive servos has continually pushed the requirements of size and speed on miniature actuators. This SBIR effort would be an attempt to investigate current miniature actuator technology from various fields and develop high quality actuators and servos suitable for UAV's sized from approximately 3 to 12 inches.

PHASE I: Working with micro UAV designers from projects such as the Organic Air Vehicle (OAV) develop a design specification for a modest range of micro UAV actuators based on the anticipated application in the on-going and planned micro UAV activities. These actuators should be designed for application to vehicles less than 12 inches in size. The design must consider the factors of weight, voltage, bandwidth, torque, reliability, rate and position saturation. Develop a preliminary design that is scalable for the range of different micro UAV applications.

PHASE II: Complete a detailed design of the miniature actuators. Build prototypes of the actuators. Bench test the actuators to determine the dynamic characteristics and reliability. Working with micro UAV developers evaluate the actuators on UAV platforms.

PHASE III: Focus on developing a commercial actuator that will be used in future micro UAV programs.

DUAL USE APPLICATIONS: The resulting technology would find use in both miniature aviation as well full scale air vehicles. Large aircraft would benefit from reliable miniature actuators on small control surfaces such as trim tabs and rotor flaps. There will also be many non-aviation applications in such fields as robotics and computer hardware. A much wider use comes from the micro UAV platforms which rely upon this technology. Micro UAVs have a wide range of use in the areas of police enforcement, security, and agriculture.

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KEYWORDS: UAV, actuator, servos.

A01-073 TITLE: Distributed Multi-Echelon Data Fusion and Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an approach to Data Fusion on a system level that will optimize the representation of the current tactical situation in most accurate and beneficial format while maintaining a common picture of the battle space among the various entities on the battle space. Investigate concepts for Data Distribution by Intelligent Agent Data Management with each node/echelon pushing and pulling the information in both hierarchical and/or collaborative distribution models.

DESCRIPTION: As the Battlespace becomes more interconnected and tactical data from a variety of sources becomes more available, it becomes imperative the best or common of picture of battle space be maintained. Key to maintaining a common picture of the battlespace and removing some of the "fog of war" is to use Data Fusion to correlate entities from all available source and track those entities as the battle unfolds. Under the Rotorcraft Pilots Associate (RPA) Advanced Technology Demonstration Program, the Army developed Data Fusion software for a Scout/Attack helicopter mission and demonstrated its usefulness. Because of power of Data Fusion, it is applicable to a wide variety of military system to include both ground and air vehicle, unmanned vehicles, Intel systems, and most level command facilities. One of the potential problems with Data Fusion is that as more weapons systems in corporate data fusion, making sure that the data is not corrupted by fusing already fused data or fusing data multiple time when it is reported by multiple systems. More over how these systems should work together to maintain a "Common Picture of the Battlefield" and make sure that they are all working on a common set of data. The problem is also complicated by the different requirements put on Data fusion by the various weapon systems and command echelon and Intel community as far as accuracy, timeliness, number of entities to be fused, and how this information is organized and analyzed.

This effort could include the following efforts:
- Develop good strategies for deciding where and when to fuse information into the common picture. Examples range from the lowest level possible, where the data are received from organic sensors, to fusion at designated, centralized fusion nodes.
- One of the key problems is to make ensure that each sensor report is fused into the common picture at any node exactly once.
- Given a tactical network with limited bandwidth, determine optimal tradeoffs for sharing raw or fused data hierarchically across echelons and laterally among peer units.
- Optimize the relationship between the amount of data transferred versus the timeliness and precision of the tactical picture.
- Fusion results shown in aggregated and possibly abstracted form.
- Evaluate strategies for sharing results of fused versus raw data.
- Determine how to best adapt the fusion algorithms and make the associated tradeoffs between timeliness, precision, throughput, area coverage etc. for the potentially diverse computing platforms: servers to handhelds, in the distributed network.

PHASE I: Analyze the information requirements for the full spectrum of command echelon, warfighters, and Intel community to determine information/fusion requirements to include content, grouping, timeliness, accuracy, intent, etc. Develop strategies managing Data Fusion among various sources and at multiple command echelon. Conduct a trade-off study of the different strategies and develop a preliminary design for a software system based on result.

PHASE II: Develop a working model for the at least 3 levels (warfighter and 2 command levels) of distribution with at least 2 systems fusing data at each level and perform constructive modeling to analyze the effectiveness of the system. Develop a High level architecture (HLA) compliant system Data Fusion Simulator form which to demonstrate and evaluate the various Data Fusion Strategies.

PHASE III: Potential military application for this product would be integrated into individual warfighter platform and command and control workstations and up the chain of command. Beyoud DOD applications, Distributed Data Fusion has application to a variety of future systes such as Autonomous vehicle control(e.g. Intelligent Highway, etc.), building monitoring (e.g. security, Smart Houses, etc.), plant monitoring (industrial uses), air traffic control for free flight, storm (weather) tracking, and vehicle traffic management (w/o the intelligent highway).

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2) D. Malkoff and A. Pawlowski, "RPA Data Fusion", presented at National Symposium on Data Fusion, Monterrey, CA, March 1996.

KEYWORDS: data fusion, common picture, multi echelon, distributed

A01-074 TITLE: Development of Effective and Practical Rotor Aerodynamic Concepts

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO, Aviation

OBJECTIVE: Develop new rotor aerodynamic concepts, specifically high lift-low drag airfoils, or other novel concepts to increase rotor lift capability, aerodynamic efficiency, and helicopter mission performance. Specifically to substantially increase the capability of future Army rotorcraft or upgrades to current systems by increasing range and payload (up to 20%), speed, and maneuverability.

DESCRIPTION: Future Army rotorcraft will be called upon to operate in ever more demanding environs than in the past, particularly for long range transport, nap-of-the-earth (NOE), deep-penetration, and air-to-air combat. Such highly maneuverable, agile, and survivable rotorcraft must have performance levels far exceeding the capability of current technology. Aerodynamic performance of conventional fixed-geometry rotor blade airfoils is currently constrained by limited clmax (maximum lift coefficient) as well as the inability of such airfoils to meet highly variable requirements at all points on the rotor disk. Aerodynamic separation and dynamic stall of current airfoils also causes significant rotor stress and vehicle vibration. To fundamentally advance rotor technology, and thereby reach new levels of rotorcraft capability, new rotor airfoil concepts are required. Potential concepts include, but are not limited to: multi-element airfoils with fixed or variable geometry slots or slats, variable geometry single-element airfoils, and steady or unsteady aerodynamic flow control concepts such as oscillatory blowing or suction, synthetic jets, or other boundary layer control concepts. These approaches must improve clmax, minimize drag, and maintain pitching moments within acceptable limits associated with rotor blade aeroelastic constraints. A significant technical challenge for such concepts is the difficulty of integrating and mechanizing such novel airfoil concepts into a practical rotor blade structure. This topic includes the development of structure and actuator concepts and mechanisms to meet this challenge in a practical, efficient, and cost effective manner. Practicality also means that the associated structural and/or actuator weight must be kept to a minimum and that blade chordwise balance requirements must be fully satisfied.

PHASE I: Candidate concept(s) as described above will be developed, analyzed, and tested with respect to performance, weight, actuation power, and evaluated with respect the potential for improving rotor lift capability, rotor efficiency, and weight. Concepts must be shown to fully satisfy practical constraints for operation on a rotating blade. Appropriate advanced airfoil concepts will be identified based on general knowledge of desirable high-lift and high efficiency characteristics. Two-dimensional airfoil performance estimates will be made as appropriate for the specific airfoil concept advanced. Concepts will be investigated in depth using appropriate aerodynamic codes (e.g. CFD codes). Phase I development will specifically address structural integration and actuation in order to evaluate the physical capabilities and overall practicality of the concept. This will include assessment of projected producability and maintenance characteristics. Component laboratory testing will be conducted if and where appropriate.

PHASE II: A detailed engineering development of the advanced rotor airfoil concepts will be undertaken. Full-scale research and engineering prototypes of the advanced airfoil concepts will be fabricated and tested. Actuator or boundary layer control systems, where applicable, will be developed and tested as well. Repetitive testing will be performed to demonstrate potential viability with respect to mechanical reliability. Two-dimensional testing of full-scale airfoil concepts will be conducted. If appropriate, a small-scale rotor system will be used for testing under Mach and Reynolds Number conditions appropriate for realistic assessment of the aerodynamic performance and efficiency. Power requirements of any auxiliary active control actuators or boundary layer control systems will be determined during the testing.

PHASE III: This technology is equally applicable to both military and civil rotorcraft. The topic addresses one of the key technical barriers to rotorcraft technology, the inherent aerodynamic performance limitations of helicopter rotors. Fundamental improvement in airfoil technology will significantly benefit both the speed and aerodynamic efficiency of the helicopter and tiltrotors. If successful, such technology will find application to nearly all future rotorcraft and likely contribute to considerable expansion of the civil rotorcraft market by virtue of significantly improved helicopter performance, and operational capability. Commercial potential is considered to be very significant.

OPERATING AND SUPPORT COST (OSCR) REDUCTIONS: This topic addresses a fundamental limitation that has existed since the invention of the helicopter. Improving the aerodynamic performance and reducing retreating blade dynamic stall with variable geometry airfoils will directly and significantly reduce the operating and support costs of rotorcraft by improving aerodynamic efficiency, thereby reducing fuel consumption; increasing cruise speed, thereby increasing productivity; and by reducing vibratory loads, thereby decreasing equipment and component failure rates and maintenance requirements.

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KEY WORDS: rotorcraft, helicopter, variable geometry airfoils, high lift, rotor performance, active control

A01-075 TITLE: Affordable High Strength Face Gears

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Advanced Attack Helicopter

OBJECTIVE: The objective of this effort is to develop and demonstrate innovative materials and/or manufacturing processes that can significantly improve the strength and durability of face gears, reduce the associated manufacturing costs and thus promote their use in high power density aerospace applications.

DESCRIPTION: Face gears are currently being developed for use in future rotorcraft main rotor reduction gearboxes (ref 1.). Face gears have the potential to achieve a much higher reduction ratio in a single stage than current bevel and planetary gears and also have the ability to be arranged in a manner that provides inherent equal sharing of the load through multiple paths. Sikorsky Aircraft and Boeing are both pursuing face gears for use in growth models of the UH-60 Blackhawk and AH-64 Apache helicopters. The inability to grind a case hardened face gear has limited past use. It is expected that a finish grinding method will be perfected in the next year by two major gear manufacturers. The current manufacturing method is to shape or form grind the face gear teeth from a forged blank. The face gear is then heat-treated (case hardened) and finish ground. The primary objective of this program is to improve face gear load capacity and production costs through the development of a manufacturing method that produces face gear blanks with near net shape teeth (ready for heat treat) and material grain orientation in a direction that enhances the fatigue strength of face gear teeth (ref 2.). In addition, the modification of currently used or emerging high hot hardness gear steels through either thermal treatment or nano level chemistry/particle manipulation is thought to have potential for additional strength and durability improvements.

PHASE I: The objective of Phase I is to conduct small scale evaluations of potential processes and materials that result in near-net shaped face gear blanks with improved strength, durability and reduced production costs. The results of these evaluations should identify the potential of the processing methods and materials and allow selection of those that should be further pursued in a Phase II effort.

PHASE II: The Phase II objectives are to further develop the selected manufacturing process and material and to optimize the specific characteristics in a production environment. Testing of multiple samples of actual face gears in either a test rig or a helicopter gearbox shall be conducted in order to establish statistical significance to the expected improvements.

PHASE III: The resulting technology will be applicable to both military and commercial aircraft, automotive, trucking, and marine vehicle markets. Low cost high power density face gears could be applicable in the drive systems/transmissions of all of these types of vehicles. Their performance and cost advantages could allow them to replace bevel /hypoid final drive gears, and planetary stages in car and truck drive systems.

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KEYWORDS: Face Gears, Near Net Shape, Heat Treatment, Gear Steels, Nano Alloying

A01-076 TITLE: An Improved Helicopter Display That Correlates Flight Symbols with Flight Imagery

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM, Aviation Eletronic System

OBJECTIVE: Traditional Primary Flight Displays (PFDs) show aircraft attitude, altitude, airspeed, and other information as graphical symbols on a panel mounted display. The objective of this research is to develop an improved panel mounted PFD for low level helicopter flight in degraded visual environments. The improved display has two features: 1.) Earth-referenced graphic flight symbols shall overlay and directly correlate with the displayed image of the terrain. 2.) The video image of the terrain will come from a variety of sources depending on visual conditions, including a fully synthetic database generated image.

DESCRIPTION: Fixed (non-gimbaled), imaging sensors may be located on the exterior of the helicopter, so any spectrum sensor can be used. Color and infrared cameras may generate the most useful images of the terrain during the day. Infrared cameras may generate the most useful images at night, and augment night vision goggles by showing a thermal image of the terrain. For flight in poor visibility weather conditions (day or night), a graphics generator coupled with GPS can produce a fully synthetic image of the terrain. The pilot will switch between terrain image sources as required by the visual conditions. One design approach that should be considered is to make the graphics overlay remain the same for all terrain image sources to allow an easy transition for the pilot. Unlike head-up displays and head-mounted displays, the field-of-view of the panel mounted display can be compressed, allowing for very wide field-of-view imaging sensors.

The image of the terrain is not, by itself, sufficient for safe flight at low altitudes. Innovative graphics must be designed to overlay on top of the terrain image to provide the pilot with critical flight information. One design approach that should be considered is to make the graphic symbols correlate with the terrain image, when it is advantageous and practical to do so. An example of correlated graphics is a velocity vector symbol which shows the location on the terrain image that the aircraft will impact if the current velocity direction remains unchanged. In addition to sensor data, database information can also be shown correlated to the terrain image such as known hazard locations and no-fly boundaries. The design of the shape, motion, correlation, and transition of graphic symbols with the flight modes of the helicopter is considered the innovative portion of this topic.

The goal of this SBIR is to enable pilots to fly helicopters in all visual conditions, including poor visibility weather, using only the panel mounted PFD. Whether pilots can safely land the aircraft in any of the non-daylight, good-visibility visual conditions using only the new PFD is currently unknown, and depends on the design of the graphics. How low and fast pilots can safely fly the aircraft with the new PFD is also currently unknown. The new PFD with correlated graphics and the terrain image described in this topic is a radical departure from traditional night vision panel mounted displays which typically do not transition between different visibility conditions and currently show uncorrelated graphics on top of the terrain image.

PHASE I: Evaluate existing PFD, head-up display, and head mounted display designs. Develop a candidate design of the display described in this topic for three flight modes: hover/landing, forward flight, and auto-rotation. For each of the three flight modes, deliver an animated computer file or video demonstrating the newly designed display described in this topic. The animation should include a chase aircraft view of the state of the helicopter being animated. Estimate the cost of designing, fabricating, and evaluating an actual display. Deliver a plan for the evaluation of the display.

PHASE II: Fabricate the display described in this topic, including all electronics, the imaging sensors, the database image generator, and software. Non-imaging sensors may be excluded (altimeter, airspeed, etc). First, evaluate the display in a simulator. Then evaluate the display in-flight on a helicopter. For cost and scheduling purposes, assume a helicopter with the required non-imaging sensors will be available as Government furnished equipment. Deliver a report detailing the design and evaluation of the display. Deliver all source code software. Deliver an updated animation if any symbols changed from Phase I.

PHASE III DUAL-USE APPLICATIONS:
This display is as useful to civil low level helicopter operators as it is to Army helicopter pilots. Example civil uses include emergency medical airlift, airborne law enforcement, helicopter transport to/from oil platforms, forest fire water drops, and passenger air service. There are potential uses of the improved PFD in the fixed wing community as well.

OPERATING AND SUPPORT COST REDUCTION (OSCR):
Reduce helicopter accidents. Increase the visual conditions in which helicopters may operate.

REFERENCES
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4) Evaluation of earth-fixed HMD symbols using the PRISMS helicopter flight simulator,"
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6) The Eyes of Comanche," Vertiflite, American Helicopter Society, Spring 1998.
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10) "Helicopter TERPROM: Hit or Miss?" Rotor and Wing, August 2000.
11) "GH-3000 Selected for Tiltrotor," Rotor and Wing, September 1998.
12) "The Next Generation," Rotor and Wing, February 1998.
13) "Pilot-Friendly Cockpit Benchmark of JSF Design," Aviation Week and Space Technology, July 17, 2000.
14) "Leader of the pack," Defence Helicopter, Shephard's Press, November 1999.
15) "EUROGRID shows the way," Defence Helicopter, Shephard's Press, November 1999.
16) "Top Cat," Defence Helicopter, Shephard's Press, March 2000
17) "777-200 Operations Manual," The Boeing Company, D632W001-TBC, 1994.

KEYWORDS: helicopter, display, primary flight display, PFD, night vision, panel mounted display, PMD

A01-077 TITLE: Automated Route Planning Using Geo-spacially Located Grid Cells

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a high speed cost minimization algorithms for route planning using a non-uniform, geo-spatial cell grid pattern.

DESCRIPTION: Automated route planning has been shown to benefit Army Helicopter Pilots in planning changes to their mission in real time situations on board aircraft when time is critical. The Army's Rotorcraft Pilot's Associate Program (RPA) has demonstrated this in a flight demonstration program in August 1999. RPA pre-processed available NIMA data to format it in exact 100 meter by 100 meter and 30 meter by 30 meter square spacing. The next step before using such a system in the field is to modify the algorithms so that they can accept data in a geo-spatial grid pattern corresponding to the available NIMA elevation data of 1 arcsecond by 1 arcsecond spacing. This will allow direct correlation with the maps used and with the WGS84 coordinate mapping system used by the rest of the Army. It will also result in the best "great circle" route taking into account the curvature of the earth and eliminate projection errors when mapping the earth as a flat surface.

Problems in using standard NIMA data may be identified in areas such as the change in length of a latitudinal arcsecond in meters with longitude. Another problem could be the difference in the length of an arcsecond in the latitudinal and longitudinal directions. Solutions may include requirements for different costs (or a cost multiplier) depending on north-south or east-west transversal and by latitude. Other problems that shall be investigated include the effects on visibility algorithms of the irregularly spaced data. Proposed algorithms shall be developed and prototyped in Phase I to solve the identified problems. Simplifications such as assuming that the grid trapezoids are rectilinear shall also be investigated to allow real time processing. Phase I will also identify the best candidate algorithm(s).

PHASE I: PHASE I shall investigate problems with converting current cost minimization algorithms to run using geo-spatial data. Methods of overcoming the identified problems and possible design simplifications shall be identified and used in the preliminary design and prototyping of candidate algorithms.

PHASE II: PHASE II shall further develop the best candidate(s), optimize it/them for speed and processing requirements imposed by a real-time, onboard system, and integrate and test the algorithms in a route planning system. The offeror may use the route planner of their choice to demonstrate their algorithms pending Government approval. If the offeror chooses to use the RPA route planner code it may be provided as GFE for this demonstration subject to the existing Government purpose license rights owned by the Government. The offeror will still have full SBIR rights to the algorithms developed under this effort.

PHASE III: The offeror shall identify applications for a Phase III effort. Potential areas include military and commercial decision aids where planning is important. Planning military missions, emergency medical and police response systems, robotics, space and underwater exploration are all potential applications where automated planning on a curved earth model would be beneficial. Phase III shall result in the successful implementation of the planning algorithms in an identified complex commercial or military application.

REFERENCE:
1996, Handbook for transformation of datums, projections, grids and common coordinate systems, US Army Corps of Engineers, Topographic Engineering Center, TEC- SR-7, http://www.tec.army.mil/news/DT&CC_Handbook.html

KEYWORDS: algorithms for route planning, geo-spatial cell grid pattern, route planning systems

A01-078 TITLE: Wireless Rotor-Mounted High-Speed Data Acquisition System

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Design and demonstrate a telemetry based rotating high-speed data acquisition system. The compact expandable system is intended for acquiring small to large number of analog channels and transmitting digital data using wireless communication.

DESCRIPTION: Typically research helicopters are equipped with ten to a few hundred transducers on the rotor blades. Slip rings are used commonly to transmit signals from transducer on the rotating blades to the non-rotating frame. The signals are then conditioned and digitized by a ground based data acquisition system. The data system can be located ten to a few hundred feet away from the transducers. Signal loss and noise interference may result due to these distances. For large numbers of transducers, slip ring becomes impractical. A rotating data acquisition system requires a few slip ring channels for signal condition and transmission power but it would drastically reduce or eliminates transmission noise problems. The data system could be mounted on top of a rotor hub and would transmits digitized data signals through wireless communication. This type of system has not been attempted for this application or for the difficult environmental conditions common to helicopter rotor heads. Desired characteristics of such a data system are listed below.

1) Operating conditions: 150 to 900 RPM, +/-4G peak-to-peak vibration, 200 knot, 0 to 5000 ft altitude, 40 to 140*F.
2) Data acquisition: On-board rotating data system can be operated at time-based and rotor synchronized sampling rate. The programmable rotor-synchronized sampling rate can be set at 256, 512, 1024, 2048 samples/rev per channel. The time-based sampling rate can be adjusted at least between 640 to 30720 Hz per channel. Input voltage can vary between 10 mV to 10V with at least 50% over-range protection. Overloaded or under-ranged channels should be marked upon data acquisition. Phase correction should be applied to all rotor-synchronized data. All acquired data should have at least 16-bit resolution.
3) Signal conditioning: Prior to digitization, all voltage signals should be pre-conditioned with programmable gain setting at 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000. Anti-alias filter should be set accordingly. On-board digital filter can be used. Auto balancing and shunt calibration should be included for each channel.

4) Modularization: Each module is capable of acquiring at least 16 channels simultaneously with at least 2 Mbyte data buffer per channel. Up to 16 modules can be connected together for simultaneous data acquisition.
5) Telemetry: Up- and down-link data must be transmitted at least 10 Mbit/s through wireless technology compliant with IEEE 802.11 and 802.3. The ground station receiver can be located at least 1000 ft away from the on-board system.
6) Power: No more than 12 slip rings can be utilized to supply DC power for the rotating data acquisition system.

PHASE I: Develop a feasible design for the data system described above with wireless communication between rotating and ground stations.

PHASE II: Prototype and demonstrate at least one 16-channel data system operating at 2048/rev and 900RPM with wireless communication between rotating and ground stations.

PHASE III: Conduct additional engineering development for the complete data system including communication among all modules, data acquisition system hardware, software libraries and user interface displays. Engineering development to include perform qualification tests and a procurement specification.

Development of the wireless data acquisition system would have application to both military and commercial sectors. This type of data system could lead to an automated track and balance system that could drastically improve the vibration environment in both military and commercial helicopters. It could, also, enable future innovative concepts utilizing individual blade control for benefits in helicopter performance, vibration and noise.

REFERENCES:
Sieverding, C. H.; Vanhaeverbeek, C.; Schulze, G., "An opto-electronic data transmission system for measurements on rotating turbomachinery components", ASME, International Gas Turbine and Aeroengine Congress and Exposition, 37th,Cologne, Germany, June 1-4, 1992

KEYWORDS: Data Acquisition System, Wireless Telemetry, Helicopter Rotor, Signal Conditioning, and Modularity.

A01-079 TITLE: Cooled CMC/Monolithic Ceramic Nozzle Development for

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Utility Helicopters

OBJECTIVE: The objective of this effort is to design and fabricate a CMC/Monolithic nozzle combination taking into account the cooling circuits, sealing surfaces and mounting of the monolithic in the ceramic matrix composites (CMC). This technology which will increase efficiencies, increase rotor inlet temperature and decrease cooling flow will have a positive impact on reducing Operating and Support (O&S) costs for future helicopters.

DESCRIPTION: To achieve the Integrated High Performance Turbine Engine Technology (IHPTET) performance requirements increased turbine operating temperatures are necessary. These higher temperature conditions require the use of advanced materials such as ceramic matrix composites for turbine vanes and in some cases, monolithic ceramics. This technology is critical for Future Transport Rotorcraft (FTR) engine to enable 20T/1000Km lift capability for Future Combat Systems (FCS) in the Objective Force.

PHASE I: Working with a gas turbine engine manufacturer, design a CMC/Monolithic nozzle combination paying particular attention to cooling circuits, sealing surfaces and mounting of the monolithic in the CMC.

PHASE II: In conjunction with a gas turbine engine manufacturer and utilizing the results from Phase I, optimize the Phase I design and fabricate components for testing. Construct a CMC/Monolithic nozzle segment for further component testing in order to reduce the risk for engine design and test.

PHASE III: The resulting technology will be beneficial to both the military and commercial sectors, being applicable to a wide variety of applications such as the tank, automotive, aircraft, as well as, any other market using engines.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Technologies which lead to higher efficiencies, increases in rotor inlet temperature and decreases in cooling flow will have a positive impact on reducing O&S costs for future helicopters.

REFERENCES:
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2) R.W. Rice, "Mechanisms of toughening in ceramic matrix composites,"
Ceramic Engineering and Science Proceedings, 2 [7-8} (1981) 661-681.
3) A.G. Evans and D.B. Marshall, "The mechanical behavior of ceramic matrix composites,"
Acta Metall. 37 37 [10] (1989) 2567-2583

KEYWORDS: Gas Turbine Engine, Turbine Nozzle, CMC's, Monolithic Ceramics, Turbine Vane

A01-080 TITLE: A Preliminary Design Tool for Shrouded-Fans

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO, Aviation

OBJECTIVE: Develop an efficient computational design and analysis tool that will enable rapid computation of shroud-fan aerodynamic performance and flow field under non-axial conditions.

DESCRIPTION: The shrouded-fan is a key component of the US Army's present and future transportation systems. The fan-tail of the RAH-66 is a classic example of the shrouded-fan. The Millennium Jet's ducted fan, the Micro-craft's UAV and Sikorsky's Cypher are all shrouded-fans that are under design-fabricate-test phases. The current method of improving shrouded-fan systems by the design-fabricate-test cycles takes too long, is labor intensive and costly. To optimize the design for specific shrouded-fan applications, a computational tool that is suitable for preliminary design is needed.

This computational tool must address critical flow phenomenon important to the design of shrouded-fan systems. This system must operate under various flight regimes including both axial and non-axial flight conditions. Non-axial conditions may exist due to edgewise forward flight, maneuvers or control surfaces such as exit vanes. Knowledge of shroud and fan performance and flow field under non-axial conditions is essential for performance envelope determination and control surface design. Viscous effects and separation dominate the pressure distribution on the shroud. In addition, the clearance between the shroud and the fan has an important influence on the system performance.

The US Army is seeking proposals to develop a computational tool that is fast and efficient and yet provides adequate knowledge of the shrouded-fan system performance and flow field in non-axial flow conditions.

PHASE I: Develop and show proof of concept of a fast computational tool capable of analyzing the viscous flow field and performance of shrouded-fans in non-axial conditions. Investigate and assess the utility of the tool for rapid calculation of the viscous flow characteristics in and around the shroud. Demonstrate the capability of this aerodynamic tool to adequately resolve the flow in the fan-shroud clearance region.

PHASE II: Extend the method developed under Phase I to include other components, such as exit vanes, without compromising the tool's computational efficiency. Establish the utility of the method for obtaining forces and moments on all the components of the system including the fan, the shroud, and the control surfaces.

PHASE III: The technology developed under this program would have widespread application at the preliminary design level before design-build cycles begin for both the Army and civil V/STOL communities. In addition the tool could eliminate the current build-test prototyping methodology by providing an environment for computational prototyping of a shrouded-fan concept for its entire mission. Any commercial or military helicopter which could effectively have its tail rotor replaced by a shrouded-fan could potentially benefit from this technology development. Shrouded-fans have also been proposed for both military and civilian unmanned air vehicles (UAV) including various alternative air vehicles to address search and rescue roles and commuter transportation.

REFERENCES:
1) Mendenhall, M.R., and Spangler, S.B., "Theoretical Study of Ducted Fan Performance," NASA CR-1494, January 1970.
2) Andrews, J.R., III., Riley, R.G., Jr., Rahnke, C., "Design and Testing of a Ducted Tail Rotor Concept Demonstrator for a Model 222U Helicopter," 22nd European Rotorcraft Forum, Brighton, United Kingdom, September 17-19, 1996.

KEYWORDS: shrouded-fan, computational tool, separated flow, non-axial flow

A01-081 TITLE: Advanced Lightweight, High Capacity Airborne Cargo Handling Winch System

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PM, Cargo Helicopters

OBJECTIVE: Define innovative concepts and design/develop an advanced compact, lightweight, high capacity airborne cargo handling winch system. The airborne winch system is intended for hauling or hoisting cargo at high speeds. The characteristics of the winch system are:

Operating Load
(Cargo mode) 22 Ton (maximum) at 60 ft./min (reeling in/out maximum speed)
(payout) 100 ft/min unloaded
Cable length 100 ft usable
Operate in a single or dual point hoist configuration
Total Desired weight < 2000 lbs.

DESCRIPTION: The Future Transport Rotorcraft (FTR) has a requirement to transport cargo externally via slung load(s). The FTR will be capable of attaching and dropping off external loads rapidly and automatically during night and in adverse weather. It shall include a capability to stabilize slung loads in-flight during higher speed operations without external bars/apparatus to maintain load stability. The goal is to permit greater utilization of the entire flight envelope and higher speed operations. An airborne winch system is a proposed method to stabilize the load during flight. Further research and development needs to be done to define and develope a lightweight, compact, airborne, 22-ton winch/hoist. The technical feasibility of a 20-ton airborne winch has not been proven. Significant technolgy advancements in materials and power sources need to be developed to achieve the aggressive weight and size goals for the winch system. The Heavy Lift Helicopter (HLH) utilized a hoist system and an advanced external winch system as described in the Advanced Cargo Handling Systems (ACHS) Demonstration program were fabricated and demonstrated. However, neither of those concepts could provide the technical capiblity to meet this requirement. Major subsystems of the winch include
the tension member (steel cable or composite materials), cable cutter, conductors to provide signals to the suspended hook, static/emergency brake, power source for hoisting and reversing, high-speed gear reduction, lubrication system, power connectors, speed sensors and feedback loop, temperature/pressure sensors, and torque sensor, reeling mechanism, digital cargo hook weight display and controls. Size and weight of the system are critical elements.

PHASE I: Identify, discuss and evaluate existing and new technology as possible candidate systems. Address all major elements of the winch system. Include development risk, tradeoff studies and methodology necessary for identifying, designing, and developing the system and all major subsystems. Discuss predicted effects on aircraft subsystem weight, cost, and power requirements. Recommend concepts and models for an airborne cargo winch system. Demonstrate the likelihood that new and innovative technology can achieve the design characteristics above. Define a preliminary design for a total winch system.

PHASE II: Design and fabricate a prototype demonstration system for static and operational testing. Conduct field evaluations in an operational environment.

PHASE III: Conduct additional engineering development to enhance producability, perform qualification tests, and generate procurement specification/data package.

POTENTIAL COMMERCIAL MARKET: Development and implementation of a new, smaller, lightweight airborne winch system(s) would have application to both military and commercial sectors. It would permit greater utilization of the entire flight envelope and higher speed operations during external cargo operations.

REFERENCES
Website: www.peoavn.redstone.army.mil/ich/DPD17_chinook/index.asp

KEYWORDS: Airborne Winch/Hoist System, External Cargo Load Operations, Army Helicopters, Heavy Lift Helicopters, Composites, Tension Member

A01-082 TITLE: Next Generation Visualization Techniques for Large-Scale Time-Dependent Data Sets

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Development of fast and efficient next generation visualization techniques on parallel processors for large-scale, time dependent computational fluid dynamics (CFD) data sets.

DESCRIPTION: Development of efficient techniques for the visualization of large CFD data sets are required to keep pace with the increasing capability of modern parallel supercomputers to generate such data. State of-the-art CFD simulations are time-dependent, moving body problems. They contain millions of grid points run for thousands of time steps producing hundreds of gigabytes of output. In order to understand the flow physics associated with these simulations and be able to use the results for engineering studies, post-processing techniques and especially time-dependent visualization methods need to be improved. Current methodologies exhibit deficiencies which become more apparent when applied to large-scale simulations.

The next generation techniques should directly address the large-scale aspects of the data. Fast file access techniques, such as memory mapping and remote access, are required. Since the data is typically generated on parallel supercomputers, post-processing and visualization algorithms should also be able to take advantage of multiple processors as well as other advances in both computational hardware and computer science now available even on desktop workstations. Of particular interest for time-dependent, moving body simulations is the generation of particle path (streakline) animations. Currently, this is a time and labor intensive effort which could significantly benefit from visualization advances. Developments in graphic file formats could make a single streakline computation more productive by allowing
3D manipulation and exploration of the image in place of static viewing and playback. Improved visualization techniques should handle a range of gridding strategies. Of particular interest is structured overset grids with holes. Capability should be available to consistently interpolate all the necessary information between time steps for compatibility with new temporal accuracy schemes allowing larger time steps. Efficient techniques may take advantage of any structured layout, repetition, or a priori knowledge of the geometry and dataset files. Finally, feature recognition is crucial in large data sets where manual investigation of a complete solution is not feasible.

Post-processing of large-scale, high fidelity rotorcraft CFD datasets exposes many of the difficulties and inadequacies to be addressed. For hovering rotors large, steady simulations are used to fully resolve the wake and understand the flow physics. A 61 million point overset and cartesian grid solution is available for investigation. Unsteady, moving body simulations are required for detailed resolution of hover (nonaxisymmetric) and forward flight rotorcraft configurations. A 37 million grid point unsteady calculation of a variable diameter tilt rotor (VDTR) in hover is also available for research.

PHASE I: Development and implementation of initial concepts resulting in a limited demonstration of the visualization of a large, time-dependent sample data set.

PHASE II: Refinement of Phase I visualization techniques and inclusion of a broader range of post-processing capabilities. The capabilities should be incorporated into a software product that is compatible with widely used file formats and post-processing tools and executes on a range of computing platforms.

PHASE III: Post-processing visualization tools for large-scale datasets have numerous applications to development of future commercial and military aircraft. Large-scale simulations will become more common with advances in computing power, moving from research areas into product development to address critical engineering issues and improve aircraft performance.

REFERENCES:
1) Kenwright, D., "Visualization Algorithms for Gigabyte Datasets," ACM SIGGRAPH 1997, Los Angeles, CA, August 1997.
2) Cox, M. and Ellsworth, D., "Application Controlled Demand Paging for Out-of-Core Visulaization," Proceedings of Visualization, Phoenix, AZ, October 1997.
3) Kao, D. and Shen, H., "Automatic Surface Flow Feature Visualization," AIAA paper 99-3287, Norfolk, VA, June 1999.
4) Meakin, R. L. and Wissink, A. M., "Unsteady Aerodynamic Simulation of Static and Moving Bodies Using Scalable Computers," AIAA Paper 99-3302, Norfolk, VA, June 1999.

KEYWORDS: Visualization, CFD, large data sets, parallel processing, post-processing, rotorcraft

A01-083 TITLE: Use of Crew Intent Inferencing to Augment Control of Multiple Unmanned Aerial Vehicles

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a Crew Intent Inferencer that will assist an operator controlling several UAVs through a Cognitive Decision Aiding System.

DESCRIPTION: Currently, each UAV is controlled by one or more operators in a Ground Control Station (GCS). The Army's Airborne Manned-Unmanned System Technology (AMUST) Baseline program has recently integrated limited GCS capability of a Hunter UAV system into the AH-64D Apache Longbow so that the Apache's Co-Pilot/Gunner (CPG) can fully control the Hunter air vehicle and its sensor payload. Future plans are to 1) integrate this AMUST Baseline technology into the Rotorcraft Pilot's Associate (RPA) Cognitive Decision Aiding System (CDAS), 2) to expand the technology to work with other UAVs in addition to Hunter (such as the Army's Tactical UAV, the Shadow 200), and 3) to enable a single Apache CPG to control multiple, different UAVs simultaneously.

This topic will enable the CDAS to understand the crew's plans, in real-time, on-board the Apache, by estimating (or inferencing) the human crew's intent.

A Crew Intent Inferencer would monitor the CPG's actions, and perhaps speech, the mission progress and context, the state of the manned helicopter and UAVs, and other parameters as necessary to infer the intent of the crew. The inferred intent would then allow the Cognitive Decision Aiding System to better manage the UAVs' flight paths and payload utilization with minimal direct input from the human operator.

PHASE I: Design a Crew Intent Inferencing System that can be integrated into an RPA-like CDA system suitable for the Apache Longbow which includes manned-unmanned teaming capability. Among other factors, the design shall address parameters monitored, method of inference, computing power and hardware required, latencies, and UAV control schema.

PHASE II: Implement the design in simulation. Perform a series of tests with representative operators to fine-tune system performance. Expand functionality to include simultaneous control of multiple, different UAVs.

PHASE III: Work with the Apache and Comanche Program Managers to incorporate the design into production Apaches and Comanches. This technology can be applied to other tactical air, land, and sea systems. In addition, this technology could be applied commercially to very large livestock and herding operations that use multiple aircraft, crop dusting, and aerial fire-fighting operations.

REFERENCES: none

KEYWORDS: intent inference, intent estimation, cognitive decision aiding, manned-unmanned teaming

A01-084 TITLE: Tactical Situation Display Integration

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Technology Applications Program Office

OBJECTIVE: Develop an efficient means of integrating multiple video and data streams within a single flat-panel display for use in helicopters.

DESCRIPTION: Information sources aimed to provide situational awareness to the military aviator in the "full spectrum" battlefield are becoming widely available. Data sources may include remote and/or on-platform visible, near, mid or far IR video, moving maps, imagery, threat/intelligence reports, mission planning systems, GPS locations of supporting aircraft and/or ground troops, etc. The aircraft controls and displays need to be optimized to present this information to pilots in timely, effective means. In order to prevent information overload, this information needs to be prioritized and presented only when needed. Use of expert system software techniques may be used to enhance conventional algorithms. The system must be capable of being tailored by the operator to accommodate mission needs. The system must scale and orient the video and data sources for overlay. Multiple video streams may require feature extraction or image fusion. The system must provide automated, de-conflicted placement of symbology (labels, menus, icons, etc.). The implementation must use an "open architecture" to accommodate additional sources of video/data as they become available.

PHASE I: Perform concept exploration of integration architecture alternatives for a tactical situation display. Develop an open system architecture framework and draft a software requirements specification for review. Perform trade studies of flat panel hardware alternatives compatible with the selected system architecture.

PHASE II: Develop and demonstrate a prototype tactical situational awareness display, display processor, and software to accommodate at least two video sources, and three data sources simultaneously.

PHASE III: Assist aircraft systems integration efforts to utilize the tactical situation awareness display system and architecture in Army helicopter platforms and other platforms as applicable. This technology has significant potential in commercial aviation for integration of information streams including weather reports and advisories, runway incursion advisories, airspace incursion advisories, etc. for enhanced safety especially in adverse weather conditions.

REFERENCES:

1) Adapting Information-Age Technology For the First Digitized Division, Chris Leins, Army RD&A, November-December 1999, pages 6-8.

2) Achieving Full-Spectrum Dominance Using Interoperable Sensor Capabilities, MAJ(P) Newman Shufflebarger and Michael E. Ryan, Army RD&A, March -April 2000, pages 32-33.

KEY WORDS: Displays, Situational Awareness, Image Processing, Image Fusion, Expert Systems

A01-085 TITLE: Non-Line of Sight, Near Real Time Video

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Technology Applications Program Office

OBJECTIVE: Design, build and test modifications to current real time video capability to extend transmit and receive distances significantly beyond current Line of Sight (LOS) limited ranges (typically less than 30-60 nautical miles when aircraft at altitudes from 400 to 4000 feet). Transmission is desired to/from the aircraft and remote base as well as aircraft to aircraft/UAV. Ground based relay stations are not desired for the tactical environment envisioned. A range of solutions shall be addressed which allow air-to-air and air-to-ground transmission based on relay aircraft or satellite interfaces. Solutions which minimize the requirement for dedicated, special purpose aircraft are desired.

A system is desired which will allow current rotary wing aircraft (H-6 to H-60 class) to transmit and receive near real time video to/from ground stations or other aircraft or UAVs beyond LOS. Systems currently exist or are under development which allow civil rotorcraft, military fixed wing and UAVs to transmit near real time video over LOS. Civil systems providing non-LOS capability using ground based relay stations within LOS of the transmitting aircraft are not suitable for the envisioned tactical environment. Capabilities of commercial aviation are rapidly expanding, e.g. commercial systems are currently in development which allow direct satellite broadcast to airline/corporate aircraft in flight. An extended range solution is desired based on existing or emerging military or commercial technology.

PHASE I: Current airborne video systems are adequate in quality of information obtained but are deficient in transmission range. Approaches for modification, enhancement or adaptation of existing/emerging military and commercial LOS systems to meet the non-LOS requirement shall be evaluated. Design concepts shall consider a range of capability, cost and ease of implementation. Recommended concepts shall place emphasis on definition of the approach and items whose development, packaging or integration extends the capability of existing/emerging systems to non-LOS. The evaluation shall include consideration of technical issues (bandwidth of available satellites and radios, frequency restrictions, frame rates, antenna design, weight, power, transmit/receive aircraft integration, relay aircraft/UAV integration, data security, sensitivity to jamming, etc.) and non-technical factors (cost, maturity, availability, any legal restrictions on use of commercial systems for military purposes, etc.). A baseline capability shall be established based on an UH-60L aircraft transmitting from an altitudes of 200 to 4000 ft. As a minimum, concepts shall be established based on satellite relay and a relay aircraft/UAV in the C-12 class. Develop overall system designs that includes definition of the required ground and aircraft components of the system and provide a recommended design for further development.

PHASE II: Develop and integrate a prototype system which eliminates or reduces current system range deficiencies and demonstrates the desired military utility. Conduct proof-of-principle development tests, field experiments, and an assessment of operational suitability and producibility. The bidders are free to propose any development efforts or equipment constrained only by the stated non-LOS real time requirement and the suitability for incorporation in the baseline aircraft types.

PHASE III: Video transmission from rotary and fixed wing aircraft and UAVs is becoming common in both military and civil applications. This system could be used to extend the range and flexibility of these systems. Additional field demonstrations will be conducted as applications for additional platforms are developed.

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2) http://www.janes.com/micro_sites/farnborough/aircraft_info/lockheed_f-16_02.shtml
Project Gold Strike is to demonstrate transmission and reception of video images from the F-16C.
3) http://www.ets-news.com/gold.html
4) http://www.etsnews.com/gold.html Description of Gold Strike hardware and capability.
5) http://www.gvmag.com/issues/2000/0200/stories/0200.security.shtml
6) http://www.gvmag.com/issues/2000/0200/stories/0200.security.shtml Canadian civil government use of an AS 355 helicopter equipped with FLIR/Inframetrics and encrypted microwave transmission system capable of transmissions up to 30 miles in all directions.
7) http://www.floatograph.com/helicopter.htm
8) http://www.floatograph.com/helicopter.htm Radio controlled helicopter equipped with SVHS video camera and video transmitter linked to a ground station for transmission up to 1500 feet from ground station.
9) http://www.ravl.co.uk/press/pr12.html
10) http://www.ravl.co.uk/press/pr12.html Racal Avionics SATCOM direct broadcast TV for in-flight passengers.

KEYWORDS: real time video, Line of Sight, Video Transmission, relay aircraft, satellite interfaces

A01-086 TITLE: Modeling and Simulation of Electromagnetic Interaction Between Composite Material Vehicle Structure and Vehicular Mounted Antenna

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PM TACTICAL RADIO COMMUNICATIONS SYSTEMS (TRCS)

OBJECTIVE: To understand the radio frequency electromagnetic interaction, coupling, between a mostly composite material vehicle and its vehicular mounted antenna. To develop model and simulation tools for the selection and mounting of multiple antennas on a vehicle build mostly of composite material to maximize communication systems performance.

DESCRIPTION: There is a need to understand and develop modeling and simulation tools for design and integration of multiple antennas on vehicle build mostly of composite material. The electromagnetic coupling of conventional metallic vehicle structure with mounted antenna elements have significant effect on radio communication, and the effect of composite material vehicle structure need to be determined. The U.S. Army CECOM is in the process of developing a set of modeling and simulation tools that is applicable to metallic vehicles, funded by the Antenna Communications Across the Spectrum (ACAS) Science and Technology Objective (STO). Tools developed under ACAS STO, such as the Communications Analysis Tool (CAT) can be reused for this SBIR.

Composite material is lightweight and strong. As the material and labor cost of composite decreases, there will be more military and commercial vehicle build mostly of composite materials, such as the U.S. Army Comanche Helicopter, and Tactical Unmanned Aerial Vehicle (TUAV). The U.S. Army Future Combat Systems (FCS) family of lightweight combat vehicle may be made of significant amount of composite material. Automotive companies are increasing the composite content of their products to increase energy efficiency, dent resistance, and other performance.

Advanced composite materials have a very wide range of electrical properties, from poorly conducting(graphite epoxy) to non-conducting(boron epoxy). To satisfy the electrical requirements of a vehicle structure, replacing metal with composite materials has its disadvantages. Some of the ground planes for antennas, lightning protection, preciptation of static, EMI/EMC, shielding effectiveness, radar cross section and power and signal ground returns. Existing antenna and electromagnetic modeling and simulation software has limited capability to analyze complex vehicle platforms constructed of varied composite and metal material.

In an increasingly connected world, we can expect more communication systems to be on board future composite material vehicles. Presently, an U.S. Army Blackhawk Helicopter installation can have 22 antenna elements. The Modeling and Simulation of Electromagnetic Interaction Between Composite Material Vehicle Structure and Vehicular Mounted Antenna can greatly aid in the integration of multiple antenna elements into future composite material vehicles to optimize communication performance.

PHASE I: Advanced composite materials can be divided into three groups; conducting fibers, non-conducting fibers and matrix materials. Investigate how various types of composite material for vehicles may affect the electromagnetic coupling of the antenna and vehicle. Develop techniques and methods to model the electromagnetic properties of complex vehicle structures made of a mix of a wide range of advanced composite materials and metal. The modeling effort should be applicable in the frequency range of 30 MHz to 2400MHz. The 30 MHz to 2400 MHz frequency bands for Very High Frequency(VHF), Ultra High Frequency(UHF), Global Positioning System(GPS), Personal Communication Services(PCS), Commercial Satellite Broadcast Radio and Industrial-Scientific-Medical(ISM).

PHASE II: Develop software that implements modeling techniques and methods developed in Phase I. Combine commercial/military off the shelf software with developer software to realize a complete modeling system. This includes modeling, meshing, solving for the electrical characteristics and viewing the outputs. Model a proposed vehicle made of composite and metallic material mounted with multiple antenna elements for the 30 MHz to 2400 MHz frequency range. Compare the results of the proposed vehicle with a similar all metallic vehicle for validation. Determine optimum antenna mounting locations, on the proposed vehicle, for a given communication system.

PHASE III: The modeling and simulation tools developed can be used in the design and integration of communication systems for both military and commercial ground, air and water vehicles. PM Tatical Radio Communications Systems (TRCS) can use the modeling and simulation tools for the system integration of the Joint Tactical Radio System (JTRS) antennas onto various platforms. The FCS Program may likewise use the developed tools to refine the antenna placement on FCS vehicle designs. Commercially, companies would ultilize these modeling and simulation tools to optimize the placement of multiples antennas (i.e. cellular phone, wireless internet service, GPS, Satellite and Terrestrial Boardcast Radio) on a single vehicle to maximize communications performance.

REFERENCES:
1) M. S. Sarto, "A new model for the FDTD analysis of the shielding performances of thin composite structures.," IEEE Transactions on Electromagnetic Compatibility, vol. 41, pp. 298-306, November 1999.
2) J. E. Richie and T. J. Barrett, " VHF Helicopter Antennas that Incorporate the Airframe and Reduce Rotor Modulation.," IEEE Transactions on Electromagnetic Compatibility, vol. 42, pp. 298-302, August 2000.
3) U. S. Government Procurements, "A ; FUTURE COMBAT SYSTEMS (FCS) COMMUNICATIONS.," Commerce Business Daily, 24 October 2000.

KEYWORDS: Antenna, composite, material, modeling, vehiicle, radio, VHF, UHF, communication

A01-087 TITLE: Netted Full Spectrum Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: Develop a full suite of state-of-the-art multi-intelligence system, which will have a flexible architecture and be fully integrated and capable of long time emplacement and long distance query. This will add a significant capability to the Army and Commander-in-Chief (CINC) which they do not presently possess, full coverage of the MASINT spectrum with a family of integrated sensors which are capable of ground and air emplacement.

DESCRIPTION: Currently the full spectrum of Measurement And Signal Intelligence (MASINT) emissions is not covered or covered by individual sensors which are not netted and do not present a common picture to the commander of the MASINT data collected. This compromises intelligence collection in urban and non-urban warfare. Presentation of forward intelligence for the full MASINT requirement in real time is also not present. Therefore, a system called Netted Full Spectrum Sensors (NFSS) have to develop.

The NFSS will provide a full suite of advanced, state-of-the art multi-intelligence sensors, ground and air delivered. This suite will be fully integrated with a flexible architecture and capable of long time emplacement, technology updates and long distance query. The sensor information will be real time/historical as the user requires. The sensor suite will include Radio Frequency Intelligence (RFINT) sensors, Chem-Bio Sensors, Seismic, Acoustic, Magnetic, Infrared, Imaging, Weather, and other types of sensors. This will provide a common family of sensor capable of covering the full spectrum of emissions/MASINT on the battlefield in both urban and non-urban environments. The sensor information will be sent to a monitor/display system both locally and remoted (stateside). All sensors will be capable of being remotely tasked and cross cueing each other.

The NFSS approach is to develop state of the art sensors utlizings mems for small size and weight, advanced miniature receivers and antennas. The transducers shall be state-of-the art mixing advanced materials for long standoff/leading edge sensitity, while maintaining acceptable level of false alarms for detections. The Phase I study will define any Commercial Off-The-Shelf (COTS)/Goods Off-The-Shelf (GOTS) transducers and transceivers to set the baseline for performance and define achievable state-of=the art improvements possible for the baseline. Phase II will develop the system subcomponents which extend the baseline performance to a 50% improvement or better. integrate them into a common baseline product, develop Low Probability of Intercept (LPI) two way data links (local and remoted) and present fused data to the commanders at every level in real time or historically as requested. Transceivers will receive taskings by three communication methodologies; Satelite communication systems (SATCOM), Unmanned aerial vehicle (UAV) mounted relays or ground relays. Emplacement of sensors will be ground (hand or robotics) or air delivered (helicopter, UAV, low flyers). All emissions whether RF, heat, chem-bio, etc., will be capable of being detected and located. The weather conditions, images of objects of interest for targeting data will be presented in a unified format for display on Digital Terrain Evaluation Data (DTED) maps to the commanders at every level. This is extremely critical when operating in urban and non-urban areas where sensors must be placed well in advance of missions during times of non-hostility. Actions leading to recommend courses of political or military action can then be monitored remotely in real time or monitored at requested intervals from within theatre or from stateside locations. All data will be presented on the SOCRATES (SOCOM) and ASAS (Army) intelligence systems as well.

The NFSS will satisfy Operational Requirements Document (ORD) requirements for REMBASS-II and Prophet Block IV for the Army, and also provide real time and on demand MASINT full spectrum coverage and data presentation in an integrated manner at all levels of intelligence from forward troops to the remote command CINC headquarters. This will support target development, counter-drug missions, and terrorist missions in urban environments for the U.S. Army and Commander in Chiefs (CINCs).

PHASE I: Define baseline performance and state-of-the art improvement envelope for transducers, receivers, processors, antennas, software, and size , weight and power considerations. Open architecture and flexibility to insert technology improvements is a key goal.

PHASE II: Develop and demonstrate the system as a unified capability to develop tactics and doctrine for a multi-intelligence ground capability. This phase will address issues related to transition to the Big Army.

PHASE III: The third phase of the SBIR will be production of the technology into a final product for baselining capability to go into the Prophet Block IV program and into commerical industry baselines.

KEYWORDS: sensors, imaging, chem-bio, seismic, acoustic, magnetic

A01-088 TITLE: Mine Detection

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM, Mines, Countermine & Demolitions

OBJECTIVE: Develop a state-of-the-art mine detection technology capable of detecting existing and next generation land mines.

DESCRIPTION: The objective is to develop advanced mine detection technologies to provide new or improved mine detection through discrimination and or identification capabilities. Novel concepts and techniques are encouraged. Technologies including, but not limited to, vapor detection, nuclear, ground penetrating radar, infrared, biotechnologies, electromagnetic, acoustic or other methods may be considered. The effort should be planned with the goal of demonstrating technologies for detection with a near 1.0 Probability of detection (Pd), sub 0.01 false-alarms per square meter at rates of advance appropriate for handheld, ground-vehicular and airborne platforms. Novel concepts for precise location accuracy of land mines or which operate at distances greater than 5 meters are of particular interest. Techniques that are slow but have a very high capability are also of great interest as a confirmation sensor. The proposed technologies shall address individual anti-tank (AT) and anti-personnel (AP) mines, whose burial depths can vary from surface laid to 20 cm below the ground surface. Burial depth is defined from the surface of the ground to the top of the target. The landmines will range in size from 4.5 cm to 38 cm (which covers AP to AT respectively) in diameter or width. Explosive fill is typically TNT, RDX or PETN. The mines may employ a variety of fuse types, including pressure, tilt rod, magnetic influence, seismic/acoustic and other sensors. Both on- and off-route mines must be considered. Sensored, off-route and side-attack mines are of particular interest. The proposed technologies are intended for use in support of a highly mobile force; therefore, rate-of-advance (OP-TEMPO) is an important factor. The Army's Future Combat System (FCS) family of vehicles are likely host platforms. Solutions requiring dedicated or specialized vehicles are not acceptable. Techniques should lend themselves to modular and bolt-on applications. Size, weight and power consumption are

important factors. Proposed technology applications should address development of hardware/software and field exercises to ascertain mine detection capability. This effort will support and leverage ongoing STO programs in Advanced Mine Detection Sensors and FCS Mine Detection and Neutralization.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of the novel mine detection technique(s) as a potential candidate for application as a tactical mine detection system. The sensitivity of the mine detection technique to discriminate mines from clutter objects will be determined . Phase I will include a demonstration to experimentally confirm/verify the lab results and analyses by utilizing a variety of mines and surrogate mines or representative components for different classes of mines.

PHASE II: The purpose of this phase is to design and fabricate a brassboard data acquisition system and to use this brassboard to experimentally confirm/verify the detection capability under varied conditions. Practical application of the technology, including proposed host-platform integration (i.e. handheld, ground vehicular and or airborne), will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, speed, Pd, Pfalse-alarm and positional accuracy.

PHASE III: This technology has numerous applications in the humanitarian demining area as well as counter terrorism. This tool could be utilized either in a joint mode with neutralization techniques or independently.

REFERENCES:
A host of information regarding the current state-of-the-art in mine detection can be obtained through the following conferences: SPIE AeroSence Conference (Detection and Remediation Technologies for Mine and Minelike Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: Landmine technologies, mine detection

A01-089 TITLE: Warrior-Centered Knowledge Management

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM Soldier

OBJECTIVE: Develop a person-centered knowledge/information management system (or key components) to optimize Cognitive Readiness for the Warrior.

DESCRIPTION: Emerging technologies will enable Cognitive Readiness to be achieved in new and innovative ways, but many of these approaches will require a person-centered system to allow an individual to manage his or her own learning progress, user profiles, repositories of information/knowledge, and interfaces (with computers or other humans). Examples include; 1) The DoD Advanced Distributed Learning (ADL) (see http://www.adlnet.org) vision is "To ensure all Americans access, anytime and anyplace, to high quality education and training tailored to their individual learning and workplace needs." This could be greatly enhanced with a person-centered system to enable individuals to increase responsiveness and manage this self-directed learning, track progress, store reference materials, certify progress, and interface to different learning systems-- what could be viewed as a person-centered Learning Management System; 2) Pocket-size wireless computers could provide warriors with access to vast amounts of knowledge (from their own stored knowledge repositories, from external sources, or from live Subject Matter Experts), but this will require a person-centered system to manage personal repositories, and to find and interface with external sources; 3) 'Situation Awareness' , Survivability, Deployability and Agility could be greatly enhanced by a person-centered system that could interface with information sources to determine what the individual already knows, needs to know, doesn't need to know, and couldn't understand anyway, plus the best way to present the information; 4) Organization-centered Knowledge Management (KM) is a major thrust in corporations and the military, but most of an organization's knowledge resides in its people. These individuals need a standards-based and person-centered system that will allow them to collect, store, and utilize this knowledge for their own purposes, plus provide access to it by others; 5) Interpersonal networking can increase one's cognitive performance, responsiveness and lethality and agility by drawing on the knowledge of others or by creating teams to complete tasks, but such interfacing is time-constrained. Intelligent agents could help with this function, but this will require a person-centered system to store information, set profiles, manage one's own agents, and interface with those of others; and, 6) The web is now providing access to the world's information, but finding what is needed is a problem. Search engines are improving, but are still far from user-centered. A robust person-centered information system (constructed for many reasons besides searches) could provide search engines with detailed personal information to enable better searches. Additionally, a person-centered information system could also be used for medical records, health/fitness management, personal finances, and family matters. Such a system could eventually be comprised of hardware, software (client and server components), services, a management system, training, technical support, external backup, and organizational controls, and as such, would likely need to

evolve over time, as key components or subsystems fall into place. These capabilities could be marketed as either net-based services (like on-line banking or brokerage services) or application products. The overall functionalities listed here will ultimately enhance and increase Deployability, Responsiveness, Agility, Lethality and Sustainability of individuals in the Objective Force.

Proposals can be for key components/applications, subsystems, or (if feasible) small-scale comprehensive systems. Offerors should show how products have potential to establish a foothold of utilization and work in conjunction with existing services and products. Components should be designed to be 'plug and play'.

PHASE I: Conduct study of proposed innovation for purposes of showing technical feasibility, benefits, and marketability. The proposed system should perform some appropriate number of the functions cited in the examples above, which could include enabling an individual (in various places, with various network connections) to search and retrieve knowledge; catalog, store, and manage knowledge for later use by self or others; find and interface with Subject Matter Experts; manage own learning, knowledge, and performance processes; maintain a reasonably accurate model of knowledge; or certify achievement of any of these capabilities. It is essential in Phase I to show how this system will be able to interface to and work along with other legacy and emerging systems (e.g., content objects, Learning Management Systems, institutional information systems, etc.), plus how it has the potential to establish a foothold of user utilization and gain dual-use product sales. Deliverables will include a technical study/plan and marketing study/plan.

PHASE II: Complete development of proposed prototype system or components, which should have dual-use market potential. Show compatibility with commercial components. Prototypes should be mature enough to attract either commercial venture capital for full product release, or additional government funding for implementation as part of government systems.

PHASE III: Commercialization of a person-centered information system (or components thereof) has huge market potential. Application areas (in addition to military) are widely varied and include person-centered financial, education, entertainment, and medical information.

REFERENCES:
DoD Advanced Distributed Learning (ADL) http://www.adlnet.org

KEYWORDS: Cognitive Readiness, information management system, knowledge management system

A01-090 TITLE: Thin Film Resistive Bolometer Semiconductor Materials Development for Uncooled Applications

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM NIGHT VISION/RECONNAISSANCE SURVEILLANCE AND TA

OBJECTIVE: Research, investigate growth techniques and processing methods, to develop a semiconductor material that is optimized for high performance, low cost, uncooled (room temperature) microbolometer fabrication. The goal is to develop a semiconductor material that exhibits properties of reasonable resistivity, high temperature coefficient of resistance (TCR), and low 1/f noise over a wide operating temperature range. In addition, the material should also be of good producibility and reliability, compatible with the current uncooled bolometer micromachining technology, and the growth techniques compatible with deposition methods on a silicon readout.

DESCRIPTION: This topic seeks to advance the technology of uncooled microbolometers through innovative investigation and development of a suitable semiconductor material for low cost, high performance, high sensitivity uncooled infrared systems. Current and past efforts have mainly focused on vanadium oxide (VOx) and amorphous silicon (a-Si) as the semiconductor material. Vanadium oxide has been shown to have moderately low 1/f noise, reasonable resistivity, but the TCR property is limited to a few percent per degree Kelvin. Amorphous silicon grown by sputtering and plasma enhanced chemical vapor deposition (PECVD) in a hydrogen controlled environment have exhibited materials with properties of high TCR, well controlled resisistivity, but high 1/f noise contributions. For uncooled systems to achieve performance approaching thermal fluctuations limits, the microbolometer materials must exhibit properties of high TCR, reasonable resisistivity, and low 1/f noise. Reasonable resistivity is desired because low or high resistance bolometer materials will present difficulties for the development of signal conditioning and readout imaging array development. Particular interest will be given to materials and material growth techniques that are compatible with the commercial foundries (Si, SiGe, GaAs, GaN and others).

PHASE I: Investigate, research growth techniques and processes to develop a semiconductor material that is suitable for high performance, high sensitivity uncooled microbolometer fabrication through the use of modeling, analysis, empirical testing or construction. Innovative materials or material growth techniques that are compatible with commercial foundries are highly desirable. Thin film growth of proposed material along with characterization results would also be desirable in phase I effort.

PHASE II: Using results of the investigation of phase I, fabricate devices, structures of the proposed materials. Test, and characterize the material's properties (TCR, resistance, 1/f ect.) To show compatibility with current uncooled micromachining technology, design, develop and fabricate a microbolometer array on a silicon substrate.

PHASE III: Transition the material growth techniques and processes to a production capable technology. The commercialization of this technology includes night driving aid, search and rescue, security, border patrol, fire fighting, and a host of other low cost infrared imaging applications.

REFERENCES:
1) M. H. Unewisse, B. I. Craig, R.J. Watson, O. Reinhold, K. C. Liddiard, "The Growth Properties of Semiconductor Bolometers for Infrared Detection", Proceedings of SPIE, Vol. 2554, pp43-54, 1996.
2) K. C. Liddiard, M. H. Unewisse and O. Reinhold, "Design and Fabrication of Thin Film Monolithic Uncooled Infrared Detector Arrays", Proceedings of SPIE, Vol 2225, pp 62-71, 1994.

KEYWORDS: Microbolometers, Micromachining, Temperature Coefficient of Resistance (TCR), Vanadium Oxide (VOx), Amorphous Silicon (a-Si), Uncooled, 1/f Noise.

A01-091 TITLE: Carbon Dioxide (CO2) Reversible Heat Pump System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Advance the state-of-the-art in carbon dioxide (CO2) reversible heat pump technology by designing and building a prototype unit capable of providing both air-conditioning at high ambient temperatures and heating at low ambient temperatures, at energy efficiencies competitive with or superior to existing fluorocarbon-based technology.

DESCRIPTION: The very high working pressure of CO2, in conjunction with its thermal properties, offers the potential of significant size and weight savings over conventional refrigerant systems. Recent breakthroughs in technology development in compressor and heat exchanger design may now allow CO2 to be employed simply and economically in a wide variety of large and small cooling and heating systems for both mobile and stationary applications. However, the development of key components is necessary to allow further development of integrated systems in the size ranges applicable to military standard families. A smaller, lighter, more efficient system will lead to a smaller power source and increased mobility for tactical users. This will directly enhance the deployability of the Objective Force.

A military standard family of Environmental Control Units (ECUs) exists, all of which operate using chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). The Army has 25,000 units fielded ranging from ½ to 5 refrigeration ton cooling capacity and the US Air Force has about 10,000 fielded units as well. Most of these units are nearing the end of their useful lives, and will have to be replaced soon. This presents an unique opportunity to "leap ahead" with the introduction of a cheap, efficient, and easily supportable refrigerant such as CO2 and reap the benefits of small size and weight, higher efficiency, and greater heating performance.

The thermodynamic properties of the transcritical CO2 cycle suggest that the system design should differ from those for conventional subcritical cycles, particularly considering performance at high heat rejection temperatures. Each overall design has its advantages and disadvantages in terms of energy efficiency, capacity, controllability, size, weight, production cost, and maintainability. A successful design will find the optimal balance of the trade-offs given the requirements and constraints of a given application.

PHASE I: Significantly advance the state-of-the-art through novel design and development of one or more of the following key components for the CO2 reversible heat pump: compressor, gas cooler, evaporator, internal heat exchanger, work recovery device, control system, or other novel components. Design and model the overall system to demonstrate its feasibility and key features, including performance characteristics over a wide range of operating conditions for cooling and heating.

PHASE II: Design and fabricate full size working prototypes in nominal 3-ton capacity as developed in Phase I. Fabricate and test these prototype ECUs to military requirements using laboratory test stands.

PHASE III: US Army and US Air Force will have direct applicability to over 35,000 ECUs now fielded. The technology will have additional spin-offs to many under-the-hood air-conditioning systems in military tank and automotive applications. Once proven in military use, the huge commercial cooling and heating market offers a tremendous number of additional spin-off applications. As can be seen in several other high-tech applications (Global Positioning System (GPS), composites, etc), military use and production methodologies can lead to eventual commercial use, lower costs, wider commercial use, and then even lower costs.

REFERENCES: Patil, A., Manzione, J., "US Army CO2 Development Program," 20th International Congress of Refrigeration, IIR/IIF, Sydney, 1999

KEYWORDS: Air-conditioning, heat pump, carbon dioxide, cooling, heating, compressor, heat exchanger, gas cooler, evaporator, expander, work recovery, refrigerant

A01-092 TITLE: Advanced Milli-Meter Wave Sensor for Multi-Function Intelligence

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: This project will investigate an advanced technique for detecting and locating radion frequency (RF) emitters by scanning the RF environment and detecting and locating RF intentional and unintentional emission above 20GHz. Technology advancement in Microwave and digital signal processing technology advancements shall be exploited to build a RF, milli-meter wave sensor for special operations and robotic vehicles that can be integrated with the MIRSS distributed sensor technology. Advanced compression techniques shall be investigated to provide reduced bandwidth RF sensor information over a common distributed sensor network. Common interface modules and remote control techniques shall be incorporated. Low power and power management technology shall be incorporated to meet the Special Operations Forces (SOF) mission requirements.

DESCRIPTION: Develop/demonstrate a lightweight, advanced surveillance microwave sensor capable of operating from 20 to 90 GHz. Investigate and assess candidate self-configurable networking architectures for post-deployment autonomous operations and communications interfaces. Specify sensor design requirements to include the embedded controller and/or RF wireless communications architecture, miniaturized Global Positioning System (GPS), direction finding, smart antenna, power source(s) and intelligent power management, MMICs, Microelectromechanical Systems (MEMS), special enclosure and packaging technologies. This technical approach will significantly reduce the inherent risk in the development, fielding and operation of an advanced, self-configurable Multi-functional, Intelligence & Remote Signal Sensor (MIRSS) system. The MIRSS is a multi-function intelligence and remote signal sensor system which can provide capabilities of target detection, location, classification, discrimination, data fusion in real time in battlefield. This enhances the the capabilities of the SOF security mission, improve their situation awareness with timely intelligence communications, and enhance their survivability. The MIRSS program will be conducted in two block: Block 1 will consist of defination and development of the MIRSS architecture and MIRSS laboratory and field demonstration experiments. The block 2 will consists of the MIRSS advanced technology studies and development.

PHASE I: Investigate MEMS-based RF, milli-meter waves technology and advanced receiver/digital signal processing technology for conceptual prototype. Model RF, milli-meter wave sensor in Future Combat Systems Distributed Interactive Simulation environment

PHASE II: Implement the phase I technical concept into a prototype sensor and field-test in a realistic military signal environment. Analyze the test data applied to military operations

PHASE III: The microwave sensor can be modifed for implementation into commercial security systems. For example, techologies (such as digital signal processing, compressing techniques, MMIC and GPS) can be integrated and interfaced with commercially available imaging. The advanced sensor can be used to detect movement of vehicles and other high value objects that use electromagnetic components.

KEYWORDS: MEMS, Modeling, Simulation, Sensor

A01-093 TITLE: Free Space Optical Communication for Distributed Command and Control On-the-Move

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The goal of this program is to develop a new generation of covert short to long range laser communications capability for multiple applications including the lower echelon maneuver and armor force, long haul data transmission, and short range sensor networking. This technology will complement the needs for high capacity multimedia information exchange for Future Combat Systems. This high bandwidth, which is intrinsic to laser communications systems, may be ideal for transmitting information that requires data rates not currently available in current military systems. This also can provide communication technology to operate during "radio silent" scenarios. A back-up RF system may be used to when the link is inoperable.

The characteristics of extremely narrow beam communications systems will be extremely advantageous to achieving the desired covertness, while at the same time operationally challenging, due to the requirement to accurately point and steer narrow beams. Innovative solutions to this problem will be sought for both technologies.

DESCRIPTION: Laser communication technologies exist commercially for fixed point-to-point applications. Pointing and tracking technologies have also been readily established for infrared countermeasures (IRCM) and target acquisition and tracking applications. The initial goal is to leverage on these technologies to show feasibility of an on-the-move laser communication system. The overall goal is to demonstrate a fielded, mobile laser communication system.
Special consideration should be made to consider the application of this technology in terms of a network centric model. Investigation of potential network configurations, which may include hybrid laser/RF systems, should be investigated to show the potential benefits of this technology. Network protocol and communication topology may be considered.

PHASE I: Develop network topology and architecture incorporating laser communication. A framework for software and hardware design should be addressed. A feasibility design will be developed. Subsystem demonstration is encouraged, if possible.

PHASE II: Develop, document, fabricate and characterize system hardware and software. Demonstrate and deliver mobile laser communication system in appropriate network configuration. Lab demonstrations and evaluations of subsystem components will be performed. Subsystems will be integrated to a full development system. Integration test will be performed in a lab environment on the entire system as well as on a High Mobility Multi-purpose Wheeled Vehicle (HMMWV) or mobile platform. A field demonstration will be conducted.

PHASE III: Commercial applications: Laser communication has a variety of applications due to its high bandwidth, "no cable" and quick installation. A high probability of commercialization is expected. Potential commercial applications include high bandwidth video transmission, building-to-building LAN backbones, long distance communication links, spectroscopy, sensor imaging, collision sensing, industrial manufacturing, chemical, environmental, and food sensing, optical routing, wavelength-division multiplexing (WDM) optical networks, bandwidth-on-demand applications, metropolitan area networks, "last mile" network connectivity, remote sensing, infrared Personal Data Assistants (PDAs), and remote computing. Military Applications: Multiple antenna remoting, distributed command and control, local area networks, and high bandwidth, fixed plant applications, on-the-move comms.

REFERENCES:
Defense Advanced Research Projects Agency (DARPA) Steered Agile Beams (STAB) Program, CECOM/DARPA Future Combat Systems (FCS) Program, US Army CECOM Free Space Optical Communication Systems Science and Technology Objective (FOCUS - STO) Program

KEYWORDS: high speed networks, high capacity communication, wavelength division multiplexing, optical networks, laser communication, infrared countermeasures, sensor networking, adaptive optics, diversity communication systems

A01-094 TITLE: Explosive-Specific Mine Detection Using Nuclear Technologies for Countermine Applications

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Nuclear Technology

ACQUISITION PROGRAM: PM, Mines, Countermine & Demolitions

OBJECTIVE: To develop a vehicle mounted, explosives specific, mine detection system based on nuclear technologies (neutron and photon techniques) that can be used as a primary sensor or, with other primary sensors, as a confirmation sensor in operational scenarios prescribed by US Army doctrine.

DESCRIPTION: The current state of mine detection is actually based on anomaly detection, whether it is electromagnetic, ground penetrating radar, infrared or other technologies. A sensor technology is required, that is either a primary or confirmatory configuration can be used to detect explosives specifically within the mine. The method applied must have a very high probability of detection (Pd) and a very low false-alarm rate (FAR) of greater than 95% and 0.001 per square meter. It must also allow the detection platform to clear a 3 meter wide and 20 kilometer long path within 3 hours. This means it must be a real time system. Innovative approaches are required to investigate and apply advanced technologies and integrate the individual components into a real time, tactical mine detection system. Recent investigations of other explosive-specific techniques, including chemical and biological, have revealed serious limitations for real time countermine applications. Thus this topic focuses on nuclear technologies, which show promise for real time, explosive-specific detection of mines. Thermal neutron activation technology appears especially promising. A variety of improved techniques, sensors and sources are available; however, application as a real time system for use under conditions encountered in the fiield requires creativity and innovation. This effort will support and leverage ongoing STO programs in Advanced Mine Detection Sensors and FCS Mine Detection and Neutralization.

PHASE I: Demonstrate in a laboratory setting the proof-of-concept. The important parameters are signal-to-noise ratio, Pd and FAR as functions of time (from exposure to recording, data processing and identification). These parameters determine the usefulness of the technology for tactical operations.

PHASE II: Design, build and demonstrate a platform mounted system in a field test that applies the confirmation configuration (one source, one detector). Test results will be analyzed in regards to applicability as a primary detection system (one source, multiple detectors) in tactical operations.

PHASE III: The Phase III commercialization of this technology will provide a significant advance in explosive detection capability with decreased false alarms. This capability has important applications in the airport and border control of explosives as well as in tactical countermine operations and in humanitarian demining.

REFERENCES:
Information regarding the current state-of-the-art in countermine technology can be obtained through the following conferences: SPIE AeroSense Conference (Detection and Remediation Technologies for Mine and Minelike Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference

KEYWORDS: Explosive detection, Neutron backscatter spectroscopy, gamma ray and x-ray spectroscopy, mine detection, countermine operations

A01-095 TITLE: Position Displacement Sensor

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a position displacement sensor to be used as an aid for self-contained navigation in areas where Global Positioning System (GPS) signals are not available (e.g. buildings, tunnels, forested areas, and high electronic countermeasures (ECM) environments). Future Combat Systems (FCS)/Objective Force applications for these sensors include the dismounted soldier, robots and other autonomous sensors in support of Command and Control (C2) and mobility.

DESCRIPTION: Sensors should be able to track relative motion with respect to the ground, buildings, terrain features, walls, floors or other objects. Potential technologies include: optical field recognition, optical flow field, optical and acoustic range finders, and floor/ground tracking velocity sensors including doppler and pedometers.

PHASE I: This effort would examine current technology and technology trends to identify opportunities for sensors to measure displacement for military operations in an urban environment. Candidate technologies would be evaluated in a trade-off study.

The top two or three selected from the trade-off study would then be further evaluated in analtical or simulation studies to determine the viability of each. Preliminary designs for integrating these sensors into an integrated navigation system would then be developed.

PHASE II: Prototypes of the viable dispalcement sensors identified in phase I would be constructed. These would be tested in the laboratory and field trials. Field tests will examine the operational utility of each technology. It is recommended that the field tests be conducted in the controlled environment at the Army's Distributed Interactive Simulation (DIS) facilities.

PHASE III: This new sensor technology development will have broad applications in the civilian community as vehicle and personal navigation is rapidly spreading throughout the commercial industry. The application of vehicle navigation is rapidly spreading to cars, taxis, buses, and trains. These platforms must maintain their navigation capability during GPS signal outages experienced within tunnels and underpasses. Additionally, a displacement would be valuable in stabilizing photography from moving vehicles.

REFERENCES:

1) Displacement measurement system for tunnel wall movement -www.physics.unlv.edu/~bill/ybox/ybox.html
2) Displacement sensor instrumentation - www.chamois.net/ixthus/index2.htm
3) Acoustic displacement sensors - www.cs.utah.edu/classes/cs6360/kolozs/acoustic/aco1.html
4) A Lie Group approach to Neural Systems for 3-D Interpretation of Visual Motion - IEEE Transactions on Neural Networks, Vol. 2, No. 1, Jan. 1991.
5) Hung, Y.; et al - A 3-D Predictive Visual Tracker for Tracking Multiple Moving Objects with a Stereo Vision System - Proc. of 3rd Int'l. Computer Science Conference, Image Analysis Applications and Computer Graphics, Hong Kong, 11-13 Dec. 1995, page 25-32.

KEYWORDS: self-contained navigation, optical field recognition

A01-096 TITLE: Integrated Remote Battlefield Surveillance System (REMBASS) - AN/PPS-5D Man Machine Interface

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: To develop an integrated display that has the capability to merge the tactical information from the Ground Surveillance Radar (GSR) and Remote Battlefield Surveillance System (REMBASS), to operate the GSR and REMBASS, and to allow an operator to generate digital surveillance information reports.

DESCRIPTION: The GSR and REMBASS provide ground surveillance of troop and vehicle movement to the warfighter. With the GSR and REMBASS emplaced in areas of threat activity, the systems are utilized to:
- Provide indications and warning of threat movement, reinforcement, or withdrawal.
- Provide near-time combat information and targeting data.
- Confirm or deny movement along major supply routes, avenues of approach or through specific named areas of interest.
- Support flank and rear security
- Vector friendly forces to objectives during periods of visibility by monitoring their movement.
- Provide tip-off and cross cueing of other sensors to support the Brigade's targeting effort.

The GSR display and REMBASS display (also know as the Advanced Monitoring Display System (AMDS)) currently utilize separate laptops. AMDS receives inputs through RS-232 Serial data format. The information within AMDS is formatted in accordance with the United States Military Text Format (USMTF) using the SALUTE specific data structure. AMDS is a Windows-based program, which is used to display multiple sensor activations and positioning in the battlefield. With ADMS, interactive map displays are selected, sensors defined, data collected, and real-time results analyzed. Arc Digitized Raster Graphics (ADRG) and Digitized Terrain Elevation Data (DTED) maps are utilized to show area of interest with elevation enhancements. The program is written in a combination of C ++ and Visual Basic. Icons representing sensors are able to be placed on the maps at given coordinates. Map tools are available that can show line-of-sight (laterally or circularly), figures, monitor log files, and alpha-numeric annotations. Up to 6 windows can be opened simultaneously.

The GSR data and control functions will be integrated into the AMDS. The integration of the data and function commands will be accomplished through the communication link between the AMDS and GSR (RS-232). As the GSR scans for battlefield targets, information is collected at every degree of rotation (azimuth) which contains 24 cells of data. This information is then

processed and sent to the AMDS to be displayed on the topographic maps. When displayed, azimuth and range Universal Transverse Mercator (UTN) is employed. Icons are generated to represent the targets. Data streams are transmitted at 19,200 Bits per second, which are binary or ASCII messages. During this process, the AMDS has the ability to valid data. The AMDS must have the capability to interrupt the data stream to response to user commands and ensure no data is lost. Through standard Windows API, AMDS will control radar parameter such as scan rate, scan coverage, elevation, azimuth, pulse width, etc. In addition, the AMDS has the ability to request to receive data up to 72 activiations per message.

PHASE I: Perform a technical/engineering analysis to determine the optimum approach of integrating the GSR and REMBASS display into single a display (via a laptop computer) and generate digital reports that shall be compatible with Force XXI Battlefield Communications Brigade and Below (FBCB2). The analysis shall include the evaluation the functionality, performance, reliability, and maintainability of the integrated display. Deliverables under Phase I should include a description of the required hardware/software, modified software modules demonstrating key integrated man-machine-interfaces (MMI) functions, and an implementation plan and cost estimates for full operational MMI/display.

PHASE II: Based upon the results of Phase I, the contractor shall develop an integrated tactical display (based on a ruggedized laptop computer) that supports the operations of the GRS and REMBASS, generates mission logs, and sends/receives reports through the FBCB2. This capability shall be successfully demonstrated in an operational field test. Deliverables under Phase II should include a description of required hardware/software, source code with documentation describing software modules, and hardware.

PHASE III: Integration software may have commercial use in integrating multiple sensors such as security systems and air traffic control and ground sensors to monitor high security areas, aircraft traffic in the air and on the ground taxi way.

REFERENCES:

AMDS Users Guide (March 01), REMBASS Technical Manual,

KEYWORDS: Ground Surveillance Radar, Remote Battlefield Surveillance System, Advanced Monitor Display System, Displays, Security Systems, Integration, Man-Machine Interface

A01-097 TITLE: Optical Networking Technologies for Tactical Army Applications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this program is to investigate optical networking architectures for the purpose of data and signal distribution for Army tactical applications. This would include developing the routing architecture, network topology, software, and hardware. Mechanisms for data transfer between wavelengths channels in the terminal interface and capability and versatility with current and future systems could be considered. This system could have uses in RF/microwave, fiber optic, and free space laser applications. The overall goal is to develop a system that would support these types of applications.

Army operational platforms can host a variety of communication equipment: satellite terminals, digital radios, tactical sensors, microwave antennas, laser communication termincals. It would be advantageous to handle the information exchange of these systems through a transparent, optical network.

DESCRIPTION: Future communications are providing network connectivity with various optical carriers. Multiple optical carriers at different wavelengths can be used to increase the information carrying capacity of existing fiber plants, to develop high capacity long haul transmission links and for optical networking. Furthermore, use of multiple wavelengths increases overall optical power carried by the system. Current commercial WDM systems are primarily use as point to point long haul links. It is desired that these networks be more adaptive to other network topologies such as wireless networking.

PHASE I: Develop network topology and architecture incorporating network components. A framework for software and hardware development should be addressed. Systems should address network interface with a variety of different communication suites (e.g. RF/microwave, fiber optic, and laser communication systems).

PHASE II: Develop, document, fabricate and characterize this system hardware and software. Demonstrate and deliver system in appropriate network configuration. System should have the versatility to interface with several types of communication systems.

PHASE III: Commercial Applications: The techniques developed under this topic will have an impact in all networking applications such as data, voice and video communications systems, intelligent highways, electronic toll collection, internet applications, cable television (CATV), satellite systems and broadcast applications. Military Applications: Multiple antenna remoting, distributed command and control, local area networks, and high bandwidth, fixed plant applications.

REFERENCES:
DARPA Web site and other DARPA Programs covering Optical Technologies, trade journals in optical networking technologies, CECOM/DARPA Future Combat Systems (FCS) Program.

KEYWORDS: high speed networks, high capacity communication, wavelength division multiplexing, optical networks, optical interconnects.

A01-098 TITLE: Structural Integrity Testing of Infrared Devices

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PM NIGHT VISION/RECONNAISSANCE SURVEILLANCE AND TA

OBJECTIVE: Develop a system for testing thin film adhesion and micro-structural strength on an individual infrared pixel utilizing a micro-force testing system. This measurement system should determine thin film metallization and passivation adhesion strength as well as measure strain within these thin films. Structural integrity testing of uncooled microbolometer suspended structures will also be determined.

DESCRIPTION: Recent advances in infrared detectors have strained the structural integrity of these systems. Miniaturization and thermal isolation have stressed the materials compatibility within an individual detector. Metallization, passivation and suspended structures all introduce strain in the detector structure. This strain induces defects in single crystal material, as well as structural failures such as peeling and chipping of thin films. This has resulted in detector failures and low producibility in several advanced infrared systems. The dimensions of the thin film and suspended structures range from approximately 100x100 to 10x10 microns. These dimensions are too small for current micro-force test systems to measure.

PHASE I: Develop a micro-force testing system that can make measurements on structures as small as 100x100 microns on a semiconductor wafer (NVESD can, if necessary, provide test structures of this dimension). Tension, compression, flex, peel, and shear measurements will be determined for these structures. The results will be correlated with bulk measurements done with the same material but for larger test areas. In addition, produce plans for a phase two effort which will shrink the size of the measurement area to 10x10 microns.

PHASE II: Design, build and demonstrate a micro-force testing system that can measure structures as small as 10x10 microns located at any position on a 3-inch diameter wafer (NVESD can, if necessary, provide test structures of this dimension). Tension, compression, flex, peel, and shear measurements will be determined for these structures. The results will be correlated with bulk measurements done with the same material but for larger test areas as well as 100x100 micron structures tested in phase 1. Deliver a prototype of this system to NVESD. In addition, produce plans for a phase three effort to commercialize this device and shrink the size of the measurement area to 1x1 microns.

PHASE III: The phase III effort includes producing a commercially viable micro-force testing system that can measure structures as small as 1x1 microns. Further improvements in this design could enable these systems to measure structural material properties of MEMS devices.

REFERENCES:
1) STO:IV.R.13 Advanced Focal Plane Arrays
2) STO:IV.R Leap Ahead Technology for High Speed IR Retinas

KEYWORDS: Adhesion, metalization, passivation, MEMS

A01-099 TITLE: Photogrammetric Camera For Rapid Prototyping

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: The objective of this effort is to conceive, develop and prototype a proof of concept Photogrammetric Camera System as well as the supporting hardware and software, tools and techniques which automate the creation of 3-D Pro-Engineer™ Computer Aided Design (CAD) models of battlefield vehicles and systems to facilitate rapid prototyping.

DESCRIPTION: Optimal applications of advanced technologies often require quick-reaction, alternative (e.g., new) systems' configurations. Often this rapid prototyping effort consists of short schedules and the use of non-inventory, prototype, emerging, foreign or variant vehicle types for the integration of these dynamic equipment configurations. The generation of a high fidelity geometry model of a battlefield vehicle such as a new Tactical Operations Center (TOC), for example, can take man-months to man-years to develop, depending on vehicle characteristics and system resolution requirements. The government desires a method of rapid and accurate 3-D model generation of these vehicles and their systems. Existing photogrammetric techniques generally capture only the gross features of objects. For military applications, the systems of interest are highly sophisticated and can be "covered" with a multitude of materials. The government desires improved techniques which not only provide a more accurate representation of the complex object's physical structure, but also provide a rapid assessment of the objects textures and materials types. This will greatly enhance our ability to respond to the changing environment that a versatile objective force must operate in.
The methods and techniques developed should be implemented in an integrated package, completely configurable via an intuitive interface.

PHASE I: The contractor shall perform an assessment of existing photogrammetric techniques, commercial digital capture systems, and related source materials. The contractor shall then develop innovative methods and techniques for rapid model development and assess the feasibility of integration with existing Commercial-Off-The-Shelf (COTS) hardware. Once this is completed, the contractor shall develop an architecture for the complete, innovative Photogrammetric Camera For Rapid Prototyping system based on the most promising technologies, methods and techniques, and develop the packaging concept required to make the technology usable. The offeror shall then provide a limited demonstration of selected techniques to demonstrate feasibility.

PHASE II: The contractor will refine and complete development on the selected techniques from Phase I. The contractor will then provide demonstration of the developed algorithms and techniques applied to sample, representative, objects of interest to test adherence to theoretical and benchmark predictions. Once the algorithms and techniques have been demonstrated the contractor shall develop, prototype, and demonstrate the Photogrammetric Camera For Rapid Prototyping System per the proposed Phase I system architecture and Phase I & II design work and perform quantification tests of model accuracy with several, typical, existing Government approved data sets. Finally, a comparative cost/efficiency analysis of the total system developed versus existing approaches shall be prepared.

PHASE III: There is an exploding demand for high fidelity 3D models in a variety of fields both in the commercial and military sectors. Having the capability to photograph a vehicle, and then rapidly generate its 3-D model, would be of great benefit in such areas as computer vision, enhancing virtual collaborative engineering, and increasing the fidelity of constructive and distributed simulations.

REFERENCES:
1) A variety of information on various aspects of photogrammetry are available from the American Society for Photogrammetry & Remote Sensing http://asprs.org/ and the International Society for Photogrammetry and Remote Sensing http://www.isprs.org.
2) General information on ProEngineer CAD software can be obtained from the Parametric Technologies web site http://www.ptc.com/products/proe/index.htm as well as other places on the web.

KEYWORDS: Computer Aided Design, Virtual Prototyping, Modeling, photogrammetry

A01-100 TITLE: Acoustic Canopy MASINT System (ACMS)

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet , LTC Stephenson

OBJECTIVE: Develop state of the art emplacement system for deployment of minature accoustic array of transducers including solar charger parachute and deployment tubes which are capable of deployment from the Shadow 200 Unmanned Aerial Vehicle (UAV) , prototype and evaluate utility of acoustic array for location and tracking of personnel and vehicles in densely treed areas.

DESCRIPTION: Currently sensor operation in densely wooded areas are very limited in capability. Hand emplaced sensors are difficult to emplace due to high risk involved in entering such environments. A system named ACMS that can provide a very small accurate acoustic sensor capable of being air dropped with a parachute from the Shadow 200 UAV is required, to allow it to be suspended from trees in densely treed areas is needed. The Parachute shall act as a solar charger for the system and the fiber optic cord from which the transducer is hung will act in the dual mode to provide the antenna functionality and communications as well as electrical connectivity for charging the sensor.

This will require state-of-the-art improvements in solar flexible, yet survivable materials. Strong fiber optic/dual mode capability, and incorporation of transducers capable of surviving the environment from a vibration standpoint. The system will incorporate technology for the development of Low Probability of Intercept (LPI) data links and present the data to the commanders at the local level in real time. Emplacement of sensors will be air delivered from the shadow 200 UAV. The parachutes will be such that there is a high probability of the parachute and associated sensor being hung in the canopy thereby allowing for better acoustic operation. All personnel and vehicle will be detected, located, and tracked. The sensors will be self-locating and form and integrated array for the purpose of location and tracking. Data will be presented in a unified format for display on Digital Terrain Evaluation Data(DTED) maps to the commander. This is extremely critical when operating in remote areas where sensors hand emplacement exposes troops to high risk of compromise. The ACMS will be real time and feed into the common family of sensors proposed under Netted Full Spectrum Sensors (NFSS) in both urban and non-urban environments. The sensor information will be set to a local monitor/display system. It will be capable of cross-cueing other sensors. This will add a significant capability to the Army and Commander-in-chief (CINCs) which do not possess the ability to locate and track personnel and vehicles in densely wooded areas.

The air emplacement of ACMS acoustic sensor arrays will satisfy the requirement for personnel and vehicle location and tracking in densely treed area without exposing ground troops to comprise. AMCS will satisfy Operational Requirements Document (ORD) requirements for Remotely Monitered Battlefield Sensor System (REMBASS-II) and Prophet Block IV for the Army, and also provide real time and on demand Measurement and Signature Intelligence (MASINT) coverage and data presentation at local levels of intelligence. This will support target development, counter-drug missions, and terrorist missions in remoted densely treed areas for the U.S. Army and Commander in Chiefs (CINC)s.

PHASE I: Develop criteria for design of a solar charging parachute with fiber optic capability and state of the art transducers and accoustic array software for the system in a package capable of deployment from the shadow 200 uav.

PHASE II: Develop , demonstrate and deliver the processing algorithms and RF netting. Also the parachute/deployment considerations will be developed and evaluated.

PHASE III: Transition this program to a production prototype for testing and evaluation of tactics and doctrine for the deployment of this capability. Examine dual use transitions as well as transitions to the Prophet Block IV programs.

KEYWORDS: tracking, sensor operation, acoustic transducers and transceivers, acoustic sensor, Netted Full Spectrum Sensors (NFSS)

A01-101 TITLE: Low Profile Near Vertical Incident Skywave (NVIS) High Frequency (HF) Vehicle Antenna

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM TACTICAL RADIO COMMUNICATIONS SYSTEMS (TRCS)

OBJECTIVE: Develop a vehicle type High Frequency (3-30 MHz) antenna for wheeled or combat vehicles or Tactical Operation Control (TOC) applications. Radiation pattern should support Near Vertical Incident Skywave (NVIS) propagation, ALE nets, and possess a low profile to avoid contact with obstructions such as tree limbs and power lines.

DESCRIPTION: Previous vehicle mounted HF antennas tended to be vertical whips that would propagate (radiate) horizontally (perpendicular to the whip). The effective range would be ap-proximately up to 75 Km using ground wave effects. Today's Army helicopters use long horizontal pipe style antennas oriented along the length of the airframe that radiate perpendicular (outward) and upward. This NVIS technique, the ability to radiate High Frequency radio waves from the ground upward to reflect them off the layers of the ionosphere and back to the ground, supports HF communications when stations are Beyond Line of Sight (BLOS). To coincide with the NVIS method, ground antennas located on mobile platforms such as High Mobility, Multi-purpose Wheeled Vehicles (HMMWVs) and TOCs require an antenna compatible with NVIS. The antenna (system) must not interfere with weapon systems such as mounted on turrets and be safe for soldiers to operate (transmit) while on the move or while stationary. Height of antenna (profile) must accommodate the vehicle moving in areas where it could come in contact with low-lying tree branches and/or power lines.

PHASE I: Survey two mobile platforms, a High Mobility Multipurpose Wheel Vehicle (HMMWV) and a Shelter Tactical Operations Center. Prepare an initial design of the antenna and perform a prediction of the propagation patterns covering the HF range of 2-30 MHz. Submit a report providing a design and how the antenna would be safe for soldiers riding in each of the two platforms.

PHASE II: Fabricate one prototype antenna for each of the two mobile platforms and install on each on the two vehicles for testing. Submissions shall be: 1. Safety Report 120 days after award, 2. Installation instructions and Test Plan 60 days prior to start of the test and 3. A Test Report 60 days after the conclusion of the testing.

PHASE III: Application to commercial services requiring communications in valleys or behind mountains using NVIS; ground platforms, communicating with other ground stations and/or supporting aviators. US Government Services and/or Agencies or foreign Countries that operate in mountainous terrain requiring HF-NVIS communications on a mobile platform.

REFERENCES: High Frequency Nap-of-the-Earth Communications, Tactics, Techniques and Procedures; April 10, 2000

KEYWORDS: Propagation, modeling, radio, NVIS, High Frequency radio, Low-Profile, Antenna

A01-102 TITLE: Development of Advanced Technologies for Fabrication of Microchannel Plates (MCPs)

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PM Night Vision, Close Combat Systems

OBJECTIVE: Leverage fabrication technologies from the semiconductor and other commercial industries to develop a microchannel plate (MCP) having improved resolution, modulation transfer function (MTF), signal amplification, and outgassing characteristics in comparison to MCPs fabricated by conventional glass processes. This would make possible image intensifiers with significantly enhanced imagery throughout all scene conditions. This technology could also enable image intensifiers which are smaller, lighter, and less expensive than the present-day devices.

DESCRIPTION: MCPs form the heart of image intensifiers, certain high speed displays, and scientific devices. An MCP is a thin wafer structure composed of millions (often more than ten million) closely-packed microscopic tubes, or "microchannels". Each microchannel acts as a discrete electron multiplier in a vacuum environment: photons, ions, or photoelectrons (as in intensifiers) enter one side and strike a microchannel wall, thereby initiating a cascade of hundreds to thousands of secondary electrons, which then exit the other side of the microchannel. For the past thirty years, MCPs have been fabricated via the glass fiber drawing techniques originally developed for fiber optics. Glass rods/tubes are put together, thermally softened, drawn down to reduce their size, reassembled and drawn down again, and reassembled/sliced into wafers; these wafers are then chemically etched/processed, reduced to yield ohmic conduction, and electroded in an extensive multi-step process. This process has been greatly refined over the years, but it is now approaching fundamental limits in cost (several hundred to $1000 per MCP), microchannel pitch (4-6 microns) and noise figure (1.5-1.6). Furthermore, MCPs degrade intensifier MTF such that only about 75% of the MCP's Nyquist Limit is typically realized, and the MCP's outgassing (mainly hydrogen and oxygen) during operation is the primary limiter of intensifier life, unless the MCP incorporates an ion-barrier film. Unfortunately, this ion-barrier film further degrades noise figure to the 1.8-2.2 range. Finally, photoelectron scattering off the MCP webbing gives rise to intensifier "halo", historically one of the most intractable intensifier artifacts.

Innovative technologies such as photolithography, advanced etching techniques, thin-film deposition techniques, and semiconductor wafer materials could yield a next-generation MCP having a greatly improved geometry and matrix material. This could enable an intensifier with much enhanced resolution, MTF, signal-to-noise ratio, and halo. Alternatively, these

advances could be exploited to fabricate much smaller/lighter intensifiers with no loss of performance. These technologies should also greatly reduce the number of MCP fabrication steps, thereby yielding a significantly less expensive MCP and intensifier tube in any application.

PHASE I: Identify promising techniques, materials and equipment, and perform initial feasibility assessments. These assessments shall comprise not merely engineering analysis, but also actual etching, processing, and electrical experiments. The intermediate products shall be test data, including electrical and microscopic characterization of experimental structures. It is highly desirable that such testing also include operational tests of MCP structures in a vacuum demountable station. The final product shall be a detailed developmental plan for attaining the following goals: channel pitch not greater than 4 microns; surface open area ratio not less than 90%; and significant reduction of noise figure, halo back-scattering, outgassing, and the output electron spread function.

PHASE II: Implement Phase I plan by fabricating operational prototype MCPs, which are capable not only of characterization for gain and uniformity in vacuum demountable stations, but which are also capable of full characterization in Generation 4 (i.e., no ion-barrier film) image intensifier tubes. Deliveries shall include a minimum of five (5) ea. advanced technology MCPs (AT/MCPs), followed by a minimum of two (2) ea. Generation 4 tube modules incorporating AT/MCPs. The exit criteria for these AT/MCPs shall be a channel pitch not greater than 4 microns, a channel length-to-diameter ratio not less than 40, and a surface open area ratio not less than 90%. The exit criteria for the tube modules shall be a noise figure not exceeding 1.4, and a tube MTF which corresponds to a minimum 90% of the MCP's geometrical Nyquist Limit.

PHASE III: The Phase III commercialization of this technology shall target much less expensive night vision aids for law enforcement, security, and the estimated 400,000 Americans suffering from retinitis pigmentosa (night blindness). The commercialization would also target scientific devices such compact, low-cost mass spectrometers. It is anticipated that the cost reductions enabled by this technology would open up a wide range of new imaging and sensing applications which are currently impractical, in support of the OSCR goals of the Army.

REFERENCES:
SPIE 2000 International Symposium on Optical Science and Technology, Conference 4128, Image Intensifiers and Applications II, Session 1, "Silicon Microchannel Plates for Image Intensification".

KEYWORDS: Microchannel Plate, MCP, Image Intensifier Tube, Generation 4, Night Vision, Photolithography

A01-103 TITLE: <u>1 kW Man-portable Hybrid-Electric Power System using Catalytic Fuel Ignition Technology</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Project Manager for Mobile Electric Power (PM-MEP)

OBJECTIVE: Two objectives are targeted: 1) Development of a catalytic fuel ignition technology that enables efficient combustion of diesel fuels in low-compression engines. 2) Apply hybrid-electric technologies (power electronics, energy storage, controls) to enable periodic silent watch capability and to pursue benchmark system reliability improvements.

DESCRIPTION: There is an emerging military need for man-portable (<60 lbs.) power in the 1 kW range with periodic silent operating capability as demonstrated by AMC-FAST (Army Materiel Command- Field Assistance in Science/Technology) inquiries to the CECOM RDEC (Communications-Electronics Command Research, Development & Engineering Center) and PM-MEP (Project Manager-Mobile Electric Power). This emerging need is envisioned as a critical capability for the Objective Force for a multitude of tactical missions. The ability to operate in a silent mode periodically can be addressed through application of emerging hybrid-electric power technologies. The difficult technical issue is man-portability. This cannot be achieved today through the use of off-the-shelf products. There are no compression ignition engines small enough to provide 1 kW and support man-portability. There are, however, many low compression, spark ignition, gasoline engines on the market in the power range of interest. One emerging research area that offers the potential for efficient combustion of diesel fuels in these low compression engines is catalytic fuel ignition. Catalytic fuel ignition involves the use of a heated catalyst material that ignites diesel fuels in a prechamber approximately the same size/form factor as a traditional spark plug. The EPA (Environmental Protection Agency), NASA (National Aeronautics and Space Administration), and DOE (Department of Energy) have funded low levels of basic research in this area.

Catalytic fuel ignition research is extremely important to the military's efforts to reduce the size and weight of the force, reduce costs through better fuel consumption, and provide the power necessary for critical missions.

The advancement of Hybrid-electric technology and its application to military gensets is critical to achieving soldier and system survivability, and reliability goals. The hybrid approach allows for periodic silent operation as needed, and allows for short term power supply in the event of a mechanical failure.

Successful execution of this SBIR effort will result in benchmark mobility (portability), reliability, and survivability (periodic silent mode operation) characteristics critical to the Objective Force dismounted soldier and Objective Force battlefield tactical power systems.

PHASE I: Identify the critical technology barriers associated with catalytic fuel ignition, specifically associated with the efficient combustion of logistics fuels in low compression engines. Also investigate high density energy storage technologies and devices to determine feasibility of the hybrid-electric approach. Develop concepts for mission scenarios to include period of silent mode operation. Define a path for future research to develop the fuel catalyst and hybrid technologies necessary for success. Develop conceptual 1 kW hybrid-electric power system designs that leverage the benefits of catalytic fuel ignition, and capitalize on the reliability & survivability benefits of hybrid-electric technology application.

PHASE II: Execute the research path from Phase I to advance catalytic fuel technology to the demonstration phase. Conduct detailed design of a laboratory breadboard hybrid-electric power system utilizing catalytic fuel ignition. Incorporate permanent magnet or other high power density alternators, power electronics, and controls necessary to achieve on-demand silent mode power capability, and default silent mode operation in the event of an engine/mechanical failure.

PHASE III: The commercial market potential is extremely high. Currently, there is a large consumer, construction, and recreational market demand for power in this range that is being addressed by gasoline generators from a variety of manufacturers. The military market potential is also very promising. We have recently worked on programs with PM-Howitzer, JBREWS (Joint Biological Remote Early Warning System), and others with low level power needs, and survivability needs. Man-portable 1 kW hybrid-electric power systems can significantly impact these market segments, providing advantages over current products in many performance and cost areas.

REFERENCES:
http://www.smartplugs.com

KEYWORDS: Catalytic Fuel Ignition, Silent Watch, Hybrid-Electric, Generator Set, Power, Man-portable

A01-104 TITLE: Sensor and Payload Evaluation Process

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PM-Prophet

OBJECTIVE: To develop a capability to evaluate multiple sensors and payloads on Unmanned Ground Systems (UGS) and Unmanned Aerial Vehicles (UAV) under various battlefield conditions and obscurants in different terrains. To provide a simulated environment to evaluate the interaction of ground sensor fields with UAV payloads and to help evaluate the military utility of the multi-sensor environment that is expected to be part of the Future Combat System (FCS) and the Objective Force. That is, be able to duplicate a multi-sensor/multi-payload environment in a laboratory on the ground.

DESCRIPTION: The Sensor & Payload Evaluation Process will have as its prime purpose to provide a research and development capability where Radar, EO/IR, ESM, SIGINT, and MASINT sensors and payloads, and survivability equipment, hardware and software, can be evaluated.

PHASE I: Perform a study to determine how best to evaluate sensor and payload technologies that will be used with UGSs, UGVs, and UAVs. Complete a survey of the FCS and Objective Force Structure to model and evaluate a selected environment. Deliverables under Phase I should include a description of the hardware and software that will be required to attain the objective and an implementation plan with cost estimates for its completion.

PHASE II: Based upon the results of Phase I the contractor will merge payload and sensor hardware with a simulated environment to evaluate how these systems will work under battlefield conditions. Currently to evaluate these sensor & payload technologies under battlefield conditions requires using these technologies during a force-on-force exercise which is a long and costly process. The contractor shall also evaluate deployment schemes for UGVs, UGSs, and UAVs in the expected FCS and Objective Force Structure.

PHASE III: These efforts will allow the evaluation of airborne payloads and ground sensors by the Army and other government agencies for Intelligence, Surveillance, and Reconnaissance (ISR) with commercial application to law enforcement, fire departments and news media for search and rescue operations. Payloads and sensors are being evaluated by the Border Patrol, Coast Guard, and in Drug Interdiction. The Border Patrol currently uses manned aircraft to detect illegal aliens crossing the US border. UAVs and UGSs can be used for the same purpose and reduce the manpower required. Similarly the Coast Guard currently uses large manned aircraft, i.e. C-130s for search and rescue operations. The mission can be accomplished using UAVs. Drug Interdiction using manned aircraft can put the crew in danger. UAVs can be used to identify where in the jungle drug factories are operating. This evaluation capability will permit development of payloads and sensors for these and other dual use applications.

REFERENCES:
Program Executive Officer, Intelligence, Electronic Warfare and Sensors (PEO IEW&S), MG Gust, letter dated May 24, 1999 designating Communications-Electronics Command (CECOM) Intelligence and Information Warfare Directorate (I2WD) as the focal point for sensor technology efforts linked to UAVs.

KEYWORDS: Unmanned Aerial Vehicle (UAV), Unmanned Ground Sensor (UGS), Unmanned Ground Vehicle (UGV), Payload, Sensor, Modeling, Simulation

A01-105 TITLE: Energy Efficient Routing Protocol for Sensor Networks

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this SBIR is to develop an energy efficient routing protocol which is tailored to the unique requirements of sensor communication networks. This routing protocol must address certain design considerations in order to reduce the power expended and in turn extending the battery life. Such considerations include the overhead needed for finding routes, the use of low power algorithms for formulating the routing tables, and the time interval and necessity between routing updates. Ad hoc networks are multihop wireless networks where all nodes maintain network connectivity without a central administration or infrastructure. Devices in the field are battery operated and must be energy conserving in order to maximize battery life. Recent studies have stressed the need to designing protocols to ensure longer battery life. The U.S. Army Future Combat Systems (FCS) will rely heavily on the use of remote, unattended sensors for target identification, perimeter defense and operation in hostile environments. Since the sensors will be deployed via artillery and/or airdrop mechanisms, the sensor nodes must self organize into highly adaptive ad hoc networks and must be designed to operate on self-contained power for up to 60 days. For these reasons, a highly energy efficient routing protocol is vital to achieve the goals of FCS.

PHASE I: The purpose of Phase I is to explore design considerations, formulate tradeoffs, develop metrics, and provide technical performance data from simulations. Provide results in a technical paper.

PHASE II: The purpose of Phase II is to take the most promising design strategies emerging from Phase I and to design and demonstrate a software prototype in an operational environment. A complete specification, along with data of power analysis, will be provided and a final report will be written.

PHASE III: This technology has the potential to increase energy efficiency in ad hoc sensor networks dramatically. In the military, applications include unattended sensors used in FCS for target identification perimeter defence, and operation in hostile environments. Commercially, this routing protocol could aid in security applications.

REFERENCES:
1) Suresh Singh, Mike Woo, C.S. Raghavendra, "Power Aware Routing in Mobile Adhoc Networks", Proceedings of Mobicom '98, Dallas, October 1998
2) Ad hoc Mobile Networks available at: http://beta.ece.ucsb.edu/wirelessOverview.html

KEYWORDS: communications, networks, protocol

A01-106 TITLE: Autonomous Extended Depth of Field for Imaging Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision Close Combat Systems

OBJECTIVE: Provide cost effective means for autonomously extending the depth of field for a variety of sensor configurations, including fast F# (order of F#/1.2) wide field of view (30 to 40 degrees) imagers in the 0.6-0.9 and 8-12 micron bands as well as larger aperture (4" to 8"), long range sensors in the 3-5 and 8-12 micron bands.

DESCRIPTION: It is a well known phenomena in optical physics that an imaging system with a given aperture dimension will have a finite range in which objects will be in focus. In truth, this range is exactly a function of sensor aperture and wavelength, and is often quantified by the term known as "hyperfocal distance." Current military night vision equipment, including image intensifiers, Forward Looking Infrared (FLIR's), and advanced solid state sensors employ opto-mechanical devices for optimizing object space focal distances. In the case of the lower cost, man-portable sensors such as goggles, this focusing action requires a manual adjustment. For the platform mounted sensors, in some cases an electro-mechanical system responds to operator control in order to set range focus, whereas in other cases such as Driver's Thermal Viewers, the system focus is permanently set at a fixed distance. In any case, military users have expressed concerns about either the need for constant manual adjustment, or in some cases, the lack of any adjustment at all. Commcerical markets for cameras and video recorders have readily available techniques for automatically adjusting focus which may find military application, or perhaps more advanced image processing techniques could be investigated. Regardless of approach, what is needed is a "hands off" method of ensuring a given night vision sensor is able to properly focus at the desired object range without sacrificing image quality.

PHASE I: Demonstrate a laboratory proof-of-concept for at least one of the sensor classes listed above. Criteria for success will be an evaluation of image quality for a variety of objects at varying distances; a characterization of the total distance of accomodation and the speed at which distance may be varied; the ability of the technique to discriminate the proper range of interest from any background clutter; ability for the technique to operate covertly; an estimation of cost, power, and weight versus the host system requirements (head mounted, platform, etc.); and an assessment for life-cycle operation in military environments (particularly temperature over -40 to +45 C, sand & dust, etc.)

PHASE II: Refinement of technique and advanced hardware/software development to implement into smallest possible configuration. Design and build a field-testable apparatus to allow human operator evaluation. For man-portable systems, demonstrate capability to perform tasks such as "reading" a map held in hand, scanning the horizon, etc. For platform mounted systems, perform target identification tasks at varying ranges appropriate for the selected sensor parameters.

PHASE III: Transistion technology into production sensor systems, perhaps as a retro-fit "kit" where applicable.

REFERENCES:
1) Helmet Mounted Displays: Design Issues for Modern Aircraft, Rash, et. al., US Army Aeromedical Laboratory, Ft. Rucker, AL
2) "Desert Shield IR Guide"; Orentas, Zegal, and Gonzalez, USA-AMSEL-NV-TR/0071, 1990

KEYWORDS: focus, depth of field, sensors, optics

A01-107 TITLE: 5 kW Alternator Proof of Concept based on Advanced Metamaterials (Nanocomposites)

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Project Manager for Mobile Electric Power (PM-MEP)

OBJECTIVE: To design, develop, and demonstrate a hybrid excitation machine using advances in nanocomposite magnetic technology from the Defense Advanced Research Projects Agency to support the tactical and vehicle power needs of the Objective Force. Resulting proof of concept machines shall maintain/enhance voltage regulation, reduce component size and weight by 30%, and increase component efficiency by 15% as compared to conventional alternator designs currently in the Army inventory.

DESCRIPTION: The Army is interested in developing power components that are smaller, lighter, quieter, and more efficient than those currently in the inventory. The reduction in component size and weight will greatly reduce the size / weight and increase system efficiency and reliability of tactical power systems and vehicles used to support the Future Combat Systems (FCS) and the Objective Force.

The Army will use advanced composite materials to develop a hybrid excitation machine or alternator which is more compact, reliable, efficient and power dense than the current wound-rotor alternator or the permanent magnet (PM) alternator. The new advanced alternator design will incorporate nanocomposite magnetic technology, which consists of magnetic surfaces made up of particles sized on the order of 7-20 nm.

Magnetic nanoparticles show improved magnetic flux density when compared to the bulk materials currently used for permanent magnets. The result is a smaller, lighter alternator than one manufactured from conventional permanent magnets. In commercial markets, this technology would be readily usable for everything from generator set applications to electric power generation for transportation needs. The reductions in size and weight will pay immediate dividends for commercial and tactical environments. This is a big step towards the Army goal for a two-man transportable 5 kW tactical electric power set.

The alternator with the advanced composite materials must be capable of providing rated, continuous power of 5 kW at 0.8 power factor, 120/208 VAC, 50/60 Hz. The resulting design must be capable of operating within a temperature range from -45oC (-50oF) to +52oC (+125oF) at any possible relative humidity for military applications.

Innovative concepts and design shall focus on hybrid excitation technologies (wound control machines integrated with permanent magnet elements - such as nanocompositie magnets and other significant higher strength materials). Use of such materials should result in the development of a high frequency, high power density alternator that demonstrates weight reduction of 15 % and increase efficiency by 20% as compared to a conventional alternator. The design shall maintain/enhance voltage control and achieve improved thermal management – that is reduced heat produce on the rotor. The advanced alternators would require no lubrication, enhance mechanical properties at higher temperatures, and would be smaller, lighter, quieter and more efficient than current designs.

These resulting component enhancements will increase system reliability, which in turn will reduce logistic burden (fuel consumption, maintenance) and will reduce system weight, which will increase system mobility. Increased mobility and reduced logistic burden will increase survivability of the FCS and Objective Force.

PHASE I: Explore existing and future hybrid excitation technologies to come up with an alternator design that will meet the military requirements specified above. A detailed Scientific Report describing the alternator concept and providing examples of advanced composite materials shall result.

PHASE II: From the design developed under the Phase I effort, two (2) alternators for the specified power output shall be fabricated and delivered. Prior to delivery a complete set of electrical tests of the alternator using commercial power electronics shall be performed. The testing shall include environmental testing to ensure proper characteristic performance. The contractor shall also provide technical assistance for government evaluation.

PHASE III: In commercial markets, this technology would be readily usable for everything from generator set applications to electric power generation for transportation needs. The reductions in size and weight will pay immediate dividends for commercial and tactical environments. In military applications, numerous alternators currently used in tactical vehicles and generator sets would be replaced by these advanced alternators. The Project Manager for Mobile Electric Power (PM-MEP) is interested in the application of this technology it's inventoried and future tactical power systems.

REFERENCES:
http://www.darpa.mil/dso/future/metamaterials/briefings.html

KEYWORDS: Hybrid Excitation Technology, Generator Set, Alternator

A01-108 TITLE: Miniaturized Multi-channel Tuners/Receivers for Tactical Unmanned Aerial Vehicle (TUAV) Applications

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Signals Warfare and PM Prophet

OBJECTIVE: Design and build a miniaturized multi-channel tuner/receiver with electrical performance suitable for use as part of the Army Tactical Unmanned Aerial Vehicle (TUAV) Signals Inteligence (SIGINT) Payload.

DESCRIPTION: Army electronic support (ES) requirements for radio frequency (RF) emitter mapping are embodied in the TUAV SIGINT Payload. This payload is required to detect, locate, measure, and identify within a few minutes all sources of RF emissions within its area-of-interest. This requirement will become increasingly challenging to meet as the density of RF emitters is undergoing enormous growth due to the proliferation of commercial wireless technologies (cellular telephony, satellite telephony, wireless networking, etc.). The high signal densities anticipated in the near future will necessitate the use of advanced RF beamforming, co-channel interference mitigation, and superresolution direction finding (DF) techniques. These techniques in turn require as input data a multi-channel feed from a well-defined antenna array. At present, it is not possible to build a multi-channel electronic support (ES) system for TUAV applications based upon size, weight, power, cost, and complexity considerations (18 kg. including antennas, 400 watt maximum prime power, 930 cu cm. volume, less than $500K per copy) as well as based upon electrical performance considerations. A variety of efforts are underway to address the requirements for miniaturized antenna elements, and commercial advances in digital electronics are addressing miniaturization requirements for the back-end processing. The critical piece not currently addressed is the RF tuner/receiver stage within the ES payload. Target specifications for the RF tuner/receiver include: tuning range from high frequency (HF) through millimeterwave; four amplitude/phase-tracking RF channels; instantaneous bandwidths (IBW) selectable up to 500MHz; two-tone spur-free dynamic range 120dB at 10 MHz IBW, 96 dB at 100 MHz IBW, and 72dB at 400 MHz IBW; better than 3 dB noise figure; 40 watts total power consumption. The preferred form factor is 6U-VME, although alternatives will be considered.

PHASE I: Design a multi-channel tuner/receiver to achieve as best as possible the electrical performance as indicated. Through appropriate engineering analysis and/or modeling and simulation substantiate the validity of the proposed design. Identify and justify anticipated performance shortfalls, and recommend longer term solutions to address the anticipated shortfalls.

PHASE II: Build and deliver two sets of prototype hardware. Perform complete electrical characterization to assess anticipated vice actual hardware performance. Identify lessons learned and refine recommendations for longer term solutions to the identified perfromance shortfalls. Multi-channel commercial application is in wide band systems such as High Definition TV (HDTV) and satellite receivers.

PHASE III: This technology will have widespread application to DoD and Allied ES assets. This technology also has the potential to impact broadband commercial wireless systems, by enabling cost-effective interference cancellation for urban applications with severe multipath interference.

REFERENCES:
Information on Army goals for electronic support can be found via the U.S. Intelligence Center website http://huachuca-usaic.army.mil by following links to the TSM-Prophet page.

KEYWORDS: tuner, receiver, multi-channel, electronic support

A01-109 TITLE: Extended Range, All Weather, Wireless Local Area Network (WLAN) for Dismounted Applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Soldier

OBJECTIVE: Design and develop an inexpensive, extended range communications system using Wireless Local Area Network (LAN) technology to handle voice and data for Dismounted applications, including supporting hardware and software, in order to facilitate all weather squad operation and position location in dense tree foliage at a range of 1.5 to 2 km. Use of existing (COTS) technology shall be maximized.

DESCRIPTION: The increasing use of weapons capable of engaging targets at ranges beyond aided and unaided visual capabilities as well as the advent of the non linear battlefield has heightened the need for an improved communications range for Dismounted applications (such as Squads and Fire Teams which are co-located). Problems which need to be addressed are dense foliage, all weather operation, and size, weight and power consumption requirements for body carried systems. It is expected that extending the range of the wireless LAN system to 1.5 to 2 km, coupled with RF position reporting techniques with the incorporation of new GPS on a chip technology, and the ability to communicate with squad members (voice and data) through dense trees in all weather, will have the highest payoff in survivability. Antenna technology to help address these issues shall also be included under this effort, as part of the WLAN system, including the helmet mounted antenna being developed by Combat ID for Dismounted Soldier (CIDDS). Developing successful range extension, particularly one maximizing use of existing technology, would also provide inexpensive commonality of equipment as well as additional reduced fratricide benefits. Various levels of tactical security also need to be addressed, as well as co-siting with co-located teams (including possible interference with Global Positioning Satellite (GPS)), anti-jam, Low Propability of Interception (LPI), and Low Propability of Detection (LPD) characteristics of the proposed system.

PHASE I: Study, trade-offs of possible solutions, and recommended solution(s) of a wireless LAN based communications system for Dismounted applications (such as Fire and Squad teams) capable of handling voice and data, all weather operation, security, and minimum weight and power consumption constraints, while providing extended range for tactical operations. A recommendations report, including all software, hardware, or operational solutions, and detailed test plan to verify performance in Phase II prototype build, shall be provided under Phase I.

PHASE II: Design, develop, and demonstrate an Extended range WLAN prototype to meet the requirements as determined in Phase I. The system shall be tested per the proposed Phase I test plan to determine capabilities. Demonstration shall include testing in a realistic scenario.

PHASE III: Possible applications beyond military communications systems include law enforcement (FBI), emergency management (FEMA), and in-building security or LAN communications. Also, aviation, space, and industrial applications where portability, ruggedization, and weight, size and power consumption requirements are critical.

REFERENCES:
The Wireless Industry's Information Source is located at www.wlana.com. It provides a Learning Zone as well as a WLAN Directorate.

KEYWORDS: Rapid Deployment,wireless, LAN, secure, voice and data communications, extended range, ruggedized

A01-110 TITLE: Transparent, Conformable Miniature Displays

TECHNOLOGY AREAS: Sensors, Human Systems

ACQUISITION PROGRAM: PM Night Vision Close Combat Systems

OBJECTIVE: Develop transparent, conformable/flexible miniature displays. These displays will demonstrate the ability of the technology approach to provide display resolution on the order of 1000 lines per inch with full color on a 1 inch diagonal active area format. The resultant displays will provide low cost and low power light weight Helmet Mounted Display (HMD) systems with simplified optical designs. The goals of the program are to attain high transmission, low optical obscuration/visual artifacts, high conductance metal traces, matrix addressability on a conformable, transparent substrate, and a manufacturing process compatible with the conformable substrate.

DESCRIPTION: In spite of advances in HMD configurations and weapon system displays/optics, these systems have poor human factors and low user acceptance. The development of miniature transparent displays can potentially improve the performance of HMD's by simplifying the optical designs and reducing the number of optical elements, which lowers the weight, center of gravity, cost, and power of the system.

PHASE I: Demonstrate fundamental materials and processes which support matrix addressed, high resolution, transparent, conformable displays. Demonstration hardware must employ row and column addressing on conformable transparent material (with active matrix architecture as a goal), be capable of 100 cd/m--2 luminance, and be complete with supporting electronics.

PHASE II: Develop compatible materials and processes for functional transparent, conformable, miniature displays. Fabricate demonstration display devices that successfully incorporate critical design features including, but not limited to, low row/column address line resistivity, high optical transmissivity, low visual artifacts, and conformable substrate processing temperature

compatibility. The technology may be demonstrated with monochrome (full color goal) provided the technology growth path to full color is clearly defined during the Phase II effort. Demonstration displays shall have 320 x 240 (60 Hz, QVGA format) resolution minimum with 640 x 480 (60 Hz, VGA format) as a goal. Device performance parameter goals are as follows: 1.) 300 cd/m2 luminance, 2.) 5 g mass, 3.) 100 mW . Two fully functional display devices which demonstrate the ability of the technology to conform to a 40 mm radius of curvature will be delivered to the Government for performance testing and analysis. The display devices shall be delivered with all necessary support electronics to demonstrate both static and motion video imagery.

PHASE III: Full color transparent conformable displays would be beneficial to both the military and commercial sectors. Bonding a transparent conformable display to the curved fiber optic output of a night vision goggle (NVG), permits simultaneous display of the NVG image & the transparent display image, without pincushion distortion, the use of optical combiners, or a substantive redesign of the NVG. The overlay permits display of information from alternate waveband sensors, providing additive image fusion, & other graphical imagery. A transparent display within the weapon sight optical channels will provide added information such as sensor video, symbology, or an electronically configurable reticle. When combined with curvilinear optical elements, the transparent device will enable compact designs for see-through displays conformed to visor or spectacle surfaces. The commercial applications include enhancements for medical and entertainment HMD's as well as instrumentation panels overlays.

REFERENCES:
1) M. Antikainen et al., "Transparent Emissive Thin-Film Electroluminescent Display," Society for Information Display International Symposium Digest of Technical Papers, pp. 885-887, SID 2000.
2) S. Utsunomiya, "Low Temperature Poly-Si TFTs on Plastic Substrate Using Surface Free Technology by Laser Ablation/Annealing (SUFTLA)," Society for Information Display International Symposium Digest of Technical Papers, pp. 916-919, SID 2000.

KEYWORDS: Display, Transparent, Conformable, Miniature, Low Power, Lightweight

A01-111 TITLE: Heads Up Situation Awareness for the Dismounted Warrior

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier / Land Warrior

OBJECTIVE: The objective of this topic is to develop and evaluate the usefulness of situation icons superimposed on the video from a weapon sight. The Heads Up Situation Awareness capability will be designed to improve the Land Warrior's (LW) situation awareness while aiming or looking through the weapon sight. A primary capability to be evaluated is target location and friendly identification based on automatic position reports over the LW Network and Tactical Internet. This capability will directly enhance the warriors's lethality and survivability in the context of the Objective Force.

DESCRIPTION: Land Warrior (LW) will have all the required components, except the required software algorithms, to provide situation awareness during weapon aiming. On the weapon, LW will have daylight and thermal sights and a digital compass with tilt sensor. The weapon sight video with an aiming reticle goes to the Hands-Free Display (HFD). To provide situation awareness during weapon aiming, the computer will be programmed to generate icons in a perspective view superimposed on the weapon sight video. The icons will be positioned based on friendly and enemy positions in the database. These positions will be converted to a perspective view corresponding to the LW position looking in the direction of the reticle on his weapon sight.

But there are performance questions, such as how accurate must the position be to identify the target as friendly, which is related to how frequently must the positions be updated while soldiers are moving. Perhaps when the soldier is aiming his weapon in a particular direction, the LW system could initiate a search over the network for any friendlies in that sector that may not have been updated recently.

Looking at a map to locate friendlies and enemies is not feasible while in the weapon aiming mode and requires switching display modes and a mental translation of horizontal view to perspective view. One way to help the soldier to identify friendlies, as well as provide him with other situation information, is to generate a perspective view of friendly and enemy positions that overlays the weapon sight video on the HFD in the weapon aiming mode. This would help him identify friendlies that are reporting their positions to him in the direction he is looking. It could also work with a removable weapon sight for looking around corners without exposing the weapon if the digital compass and elevation sensor is located on the sight.

Heads Up Situation Awareness might also be useful on a see-through HMD. However, the LW HMD is not expected to be see-through at this time and would require a compass or attitude/heading reference on the helmet, which increases the helmet weight problem.

PHASE I: Develop a feasibility concept design based on the Land Warrior system architecture. Develop graphical user interfaces, a software development plan and a system integration and test plan. Where possible, identify off-the-shelf software that will be integrated in Phase II that satisfies most objectives and is suitable for evaluation. Estimate system resource requirements and components required for demonstration in Phase II. Provide briefings of the concept and obtain comments from PM Soldier and TSM Soldier, Battle Lab and doctrinal personnel located at Ft. Benning, GA. The design concept will be modified to incorporate comments and user preferences.

PHASE II: The Heads Up Situation Awareness software will be prototyped to demonstrate the concept. The software will be integrated with components proposed in Phase I to provide a video aiming sight and graphical overlay of friendly and enemy locations. Initial evaluations will involve infantry soldiers, preferably those trained in use of Land Warrior software, performing weapon aiming and targeting functions, to determine the performance requirements, usefulness and how to best display the information. Evaluation will also seek the input of TSM Soldier, Battle Lab and doctrinal personnel located at Ft. Benning, GA. A recommended architecture and implementation approach for transition to Land Warrior will be developed.

PHASE III: Prototype software will be refined and integrated with a government furnished Land Warrior system, if available, or similar system.

There may be commercial applications for worn or handheld video cameras in a mobile environment where situation information from a database can be superimposed on the video. One could visualize a proposed construction project before it is built or view virtual signs along a road or path. The system requires geo-referenced objects, user location, and attitude/heading of the camera. By including the computer and wireless interface, this software may also be the basis for portable games. Such games would superimpose game objects such as team members, opponents and computer generated objects over the real world view from the camera.

REFERENCES:
Land Warrior Operational Requirements Document

KEYWORDS: Land Warrior, situation awareness, fratricide, combat identification (ID), display, video sight, friendly positions, weapon aiming, wearable computer, dismounted, information technology

A01-112 TITLE: Synchronized RF Spectrum Search and Emitter Location

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: Demonstrate the capability to locate emitters on a battlefield by measuring the line of position to a target from several different locations simultaneously.

DESCRIPTION: A primary function of electronic support (ES) systems is to provide an "RF emitter map" of the battlefield. While several techniques are available for geolocation of RF emitters, the context of ground maneuver forces argues stongly for the use of simple, inexpensive, and reliable direction-finding (DF) equipment with geolocation by triangulation. However, DF reports obtained independently from multiple sensors can be difficult to correlate correctly in a dense emitter environment. A potential solution to this problem is for three or more sensor systems to search the applicable RF spectrum in synchronism. The systems would be periodically resynchronized via a reset signal from embedded GPS receivers or other precision timing sources. Once reset, each sensor would step through pre-programmed spectral regions, at precise intervals moving from one frequency to the next (an interval might be 1 millisecond, for example, facilitating stepping through the low VHF range of 30 – 90 MHz with 25 kHz channelization in 2.4 seconds). When dwelling at a frequency the presence of any signals present would be determined and a line of position (LOP) or time of arrival of the signal at the sensor would be measured. Periodically (perhaps during the following dwell interval) the results of the energy and LOP measurements, along with an indication of frequency, energy level and sensor location, would be passed to a remoted controller. The controller would calculate the geolocation of all detected emitters based on the measured LOPs, and the results plotted on a map background.

PHASE I: Design a geolocation system based on synchronous DF. The design should maximize the utilization of commercial off-the-shelf (COTS) components. A report will be delivered detailing the design to be implemented in Phase II. This report will include sufficient technical detail to ensure the integrity of the design. The report will also include the management approach for Phase II.

PHASE II: Build a complete geolocation system consisting of at least two sensor systems and one controller. The sensor systems and controller shall include all necessary components to demonstrate and measure the performance of the architecture. Any necessary RF communications shall also be provided. Conduct field tests to evaluate the performance of the deliverable hardware. A report will be submitted that documents the design and the field test results.

PHASE III: Network Centric Warfare field tests for the Army's Objective Force Experiments. This technology has potential application to civilian search and rescue including satellite and cellular 911 calls, as well as to stolen vehicle recovery.

REFERENCES:
Torrieri, D.J., Principles of Secure Communication Systems, Second Edition, Chapter 4, Artech House, Boston, 1992.

KEYWORDS: emitter location, direction finding, electronic support

A01-113 TITLE: Scalable Mobile Quality of Service (QOS) Reliable Multicast Protocol

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop scalable reliable mobile multicast protocols for both transport and IP layer that can be used to achieve Quality of Service (QOS) criteria to support applications requirements and optimize network performance.

DESCRIPTION: Future military communications networks, which will be required for the Future Combat System and being developed under MOSAIC ATD, will be highly dependent upon sophisticated protocols. These protocols will route information among highly mobile users, be independent of a backbone infrastructure and provide wide-band communications services. There are many initiatives in process both in the military and commercial sector addressing this area. Multicast protocols for wireless networks are being developed and are being exported through the Internet Engineering Task Force (IETF) and other initiatives. Current work does not address the Quality of Service particularly as it relates to reliable transmissions (confirmation of reception) associated with mobile military tactical networks. This proposed project would seek out initiatives that will provide innovative solutions to satisfy this requirement.

PHASE I: Develop techniques for the QOS for operation in hostile environments at the network and transport layer to deliver virtual real-time communication. Provide an assessment of the performance and feasibility of the proposed technique or techniques which addresses scalability and unique military performance issues of a mobile tactical network.

PHASE II: Building upon the results in Phase I development of a prototype and simulation to assess the QOS based upon efficiency, delay, reliability and robustness.

PHASE III: This can be used by the military in real-time tactical and strategic communications, as well as by commercial telecommunications providers such as ISP's and wireless communications network operators. Network operators can use a mobile multicasting protocol that will be able to deliver packets based on the QOS requirements. Such a protocol would dramatically increase efficiency and reliability of networks.

REFERENCES:
1) Quality of Service in IP Networks, "Foundations for a Multi-Service Internet", Armitage Greenville, Macmillan Technical, April 2000.
2) Quality of Service, "Delivering Q of S on the Internet and in Corporate Networks", Paul Freguson, Wiley, John & Sons, Inc. January 1998

KEYWORDS: communications, networks, protocols

A01-114 TITLE: Standoff Mine Neutralization

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PM, Mines, Countermine & Demolitions

OBJECTIVE: Develop a state-of-the-art mine neutralization system capable of neutralizing existing and next generation land mines at safe standoff distances.

DESCRIPTION: The objective is to develop advanced mine neutralization technologies to provide new or improved standoff mine neutralization capabilities. Novel concepts and techniques are encouraged. Technologies including, but not limited to, explosives, radio frequency/high power microwaves, lasers, water jets, kinetic energy or other methods may be considered. The effort should be planned with the goal of demonstrating technologies for neutralization with a 0.95 Probability of Kill (Pk) at standoff distances of 10 to 30 m. Novel concepts for precision delivery of explosive neutralizers at safe standoff distances are of particular interest. Techniques that result in minimal damage to road surfaces are also of interest. The proposed technologies shall address individual anti-tank (AT) and anti-personnel (AP) mines and unexploded ordnance (UXO), whose burial depths can vary from surface laid to 20 cm below the ground surface. Burial depth is measured from the surface of the ground to the top of the target. The landmines will range in size from 4.5 cm to 38 cm (which covers AP to AT respectively) in diameter or width. Explosive fill is typically TNT, RDX or PETN. Both "dumb" and "smart" mines must be neutralized, though not necessarily by the same technique. The mines may employ a variety of fuse types, including pressure, tilt rod, magnetic influence, mm-wave, infrared, seismic/acoustic and other sensors. Both on- and off-route mines must be considered. Sensored off-route and side-attack mines are of particular interest. The proposed technologies are intended for use in support of a highly mobile force; therefore, rate-of-advance (Operational Tempo) is an important factor. The Army's Future Combat System (FCS) family of vehicles are likely host platforms. Solutions requiring dedicated or specialized vehicles are not acceptable. Techniques should lend themselves to modular and bolt-on applications. Size, weight and power consumption are important factors. Proposed technology applications should be point or spot neutralizers as opposed to area neutralizers. The neutralizer will be used in conjunction with a forward looking mine detection system that will provide localized targeting information for individual mines. This effort will support and leverage ongoing STO programs in Advanced Mine Detection Sensors and FCS Mine Detection and Neutralization.

PHASE I: This phase will focus on laboratory and limited field investigation of the novel mine neutralization technique as a potential candidate for application as a tactical mine neutralization system. The sensitivity of the mine initiation process will be determined as well as the vulnerability thresholds for various components, subsystems, and the total system of various mine targets. Practical application of the technology, including proposed delivery mechanisms, will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, PK, and standoff. Phase I will include a demonstration to experimentally confirm/verify the lab results and analyses by utilizing a variety of mines and surrogate mines or representative components for different classes of mines.

PHASE II: The purpose of this phase is to design and fabricate a brassboard system and to use this brassboard to experimentally confirm/verify the neutralization capability under varied environmental and application conditions.

PHASE III: This technology has numerous applications in the humanitarian demining area as well as counter terrorism. This tool could be utilized either in a joint mode of detection (utilizing the detection technology referred to above) and neutralization or independently.

REFERENCES:
Information regarding the current state-of-the-art in countermine technology can be obtained through the following conferences: SPIE AeroSense Conference (Detection and Remediation Technologies for Mine and Minelike Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: Landmine technologies, mine neutralization, lethality mechanisms, countermine applications

A01-115 TITLE: 500 W Microscale Power Technology for Tactical Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Project Manager for Mobile Electric Power (PM-MEP)

OBJECTIVE: Develop technologies that leverage the advantages of microscale fabrication, microelectronics, and microscale combustion of logistics fuels, to support Objective Force tactical power needs in the 500 W range. Successful execution of this SBIR effort will result in benchmark mobility (portability), and survivability (near silent operation) characteristics critical to the Objective Force dismounted soldier and Objective Force equipment such as battlefield tactical power and remotely-operated robotic systems.

DESCRIPTION: Significant DARPA (Defense Advanced Research Projects Agency), ARL (Army Research Lab), and other resources have been applied to developing microscale engine & generator technologies in support of the Land Warrior mission. Technologies such as microscale fuel combustion; microfabrication of silicon, piezoelectric, and other materials; microscale fabrication of mechanical-to-electric devices (generators); and high-speed rotational & vibration microscale phenomena have been studied. Development of these technologies is imperative if Land Warrior operational requirements are to be met. Power requirements must be satisfied over a 72 hour mission within a 0.5 lbs. weight limitation. Projections for future Land Warrior power requirements are as low as 5 W, requiring (5 W)(72 hrs) / (0.5 lbs.) = 720 W-hrs/lb. Projections for the best primary battery energy densities are 170 W-hr/lb, far too low to support the Land Warrior mission, hence the need for investment in microscale fuel burning technology development.

In contrast to the Land Warrior mission, an area of emerging interest is the transitional power level of 500W. At the lower end of the PM-MEP's (Project Manager-Mobile Electric Power) charter for standardized battlefield tactical power, it is an impractical range for batteries of any kind to support, and cannot be practically addressed through the use of conventional off-the-shelf diesel engine-based systems. Currently, PM-MEP's smallest offering for standardized battlefield tactical power is the 2 kW genset. The 500 W power level is critical for the Objective Force, because it offers sufficient capability for battery charging, lighting, communication, and individual heating & cooling. Through the use of 2-dimensional batch microfabrication technology, a fuel burning power system can offer excellent power density at the 500 W level. Some of the more recent microscale research has shown that the technology developed for Land Warrior may be scaleable above the 20-50W level, but it is not clear to what extent scalability is possible. This will be a critical area for investigation in this SBIR.

A microscale 500 W system can exhibit the most attractive features from the battery realm (<10W) and the engine/generator realm (>2 kW). In particular, a microscale system can offer near silent operation, and exceptional power density. In addition, the potential for low fuel consumption (cost/kW), low production cost, and low maintenance costs are great. Mobility and survivability characteristics are critical to the Objective Force dismounted soldier.

PHASE I: Identify the critical technology barriers and scalability limits associated with microscale power technology at the 500 W level. Define a path for future research to develop the technologies necessary for this transitional power range, 500 W. Develop conceptual 500 W microscale power system designs that offer exceptional power density (50 W / lb.), near silent operation, and low total ownership costs.

PHASE II: Execute the research path from Phase I to advance microscale power system technology for the 500 W level. Conduct detailed design and fabrication of laboratory breadboard microscale power system components/subsystems.

PHASE III: Advanced development of a specific microscale engine/generator system configuration. The commercial market potential is extremely high. Currently, there is a large consumer, construction, and recreational market demand for power in this range that is being addressed by gasoline generators from a variety of manufacturers. The military market potential is also very promising. We have recently worked on programs with PM-Howitzer, JBREWS (Joint Biological Remote Early Warning System), and others with low level power needs. Microscale power system technology can revolutionize this market segment, providing advantages over current products in virtually all performance and cost areas.

REFERENCES:
http://www.darpa.mil/mto/; 2. http://ida.org/mems

KEYWORDS: Microengine, Microscale, MEMs, Microelectromechanical Systems, Generator Set, Power System, Portable Power

A01-116 TITLE: Expendable Radar Countermeausure Modules

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: To enhance survivability of forces similar to the Future Combat System (FCS) by significantly degrading the ability of enemy surveillance and targeting systems to locate and identify ground forces. Devise an approach to effectively accomplish this utilizing a variety of technologies, focusing on the integration of Electronic Counter Measures (ECM) techniques into a new or existing ground sensor battlefield surveillance system.

DESCRIPTION: This program will develop a Network Centric expendable radar deception and jamming modules that can be controlled by a system such as the IREMBASS' AN/PYY-1 control indicator. Ground sensor and radar systems currently support Military Intelligence (MI) units to determine activity in the battlefield. The Improved Remotely Monitored battlefield Sensor Sys-tem (IREMBASS) provides real-time information that can determine direction and classify targets. The information is transmitted to AN/PYY-1 Advanced Monitoring Display System (AMDS) or a similar functional display (control indicator) that collects and graphically displays the information on digital maps provided by the National Imagery Management Agency (NIMA). Integrating a new countermeasures module that deceives and jams enemy radar capability to locate and identify our forces, together with the I-REMBASS sensors would greatly enhance the warfighter's advantage on the battlefield.

The design and fabrication of a low-cost expendable ECM module that can be remotely controlled through the AN/PYY-1 or a similar functional display will expand the existing MI suite to exercise control of the battlefield. The threat radar activity and any deployed ECM technique will be depicted on the AMDS display where specific parameters for the device operation will also be managed.

A variety of ECM technologies that presently exist will be reviewed with emerging technologies to determine the feasibility of developing expendable radar countermeasure modules. Such mod-ules must be capable of integrating into existing and future suites that will support Network Centric Warfare and meet form, fit, and function requirements.

PHASE I: A study will be conducted of deception and jamming performance devices vs. various designs and threat radar. Threat characteristics and parameters necessary to determine the feasability of developing the countermeasures include, but are not limited to, radar frequency (RF), Pulsewidth, Pulse Repetition Frequency (PRF), waveform modulation, scan type, effective radiate power (ERP), and range. The study will also address the feasibility of operation in a remotely controlled environment, and any operational deployment considerations.

PHASE II: Design and development of a laboratory prototypes ECM models which will to be used to conduct a field test of deception and jamming performance vs. various radars. Interface and control issues will be facilitated and tested through the AMDS.

PHASE III: Develop an expendable ECM production module with high reliability, low cost, and small size with incorporation of requirements for interfacing with I-REMBASS and AMDS dis-play. A wide range of military and commercial applications exist for the "Expandable Radar Countermeasure Modules", ranging from protection of military high value assets and EW sys-tems, or use as a Unmanned Aerial Vehicle (UAV) based platform or expendable ECM decoy. Commercial application exists for any microwave receiving system that want to reject the pres-ence of interfering RF systems, such as cellular telephone, line of sight (LOS) microwave links, paging systems, satellite communication systems and collision avoidance systems.

REFERENCES:

Operational Requirements Document (ORD) for the I-REMBASS System, Applied ECM by Leroy Van Brunt, Vol. 1.

KEYWORDS: Radar, Electronic Counter Measures, ECM, Radar Deception, I-REMBASS, AMDS, FCS, CM, Jamming, Network Centric Warfare

A01-117 TITLE: Filter Design to Counter Scattering Effects Due to Foliage Canopies on VHF/UHF Communications Links

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM TACTICAL RADIO COMMUNICATIONS SYSTEMS (TRCS)

OBJECTIVE: To develop filter designs to mitigate the effects of scattering interference on VHF and UHF communications links based on link propagation analysis.

DESCRIPTION: Communications signal propagation through foliage canopies at VHF and UHF frequencies is degraded by multi-path scattering due to trees and other foliage components. Multi-path scattering appears at the receiving station as randomly displaced signal components that are delayed and distorted copies of the transmitted signal. These distorted signal components severely disrupt the received signal detection process and block communications. Filters could inversely matched to the multi-path scattering interference sources and improve the signal-to-noise ratio (SNR) at the receiver by greater than 20 dB. Improved SNRs benefit the Warfighter by increasing communica-tions range and message reliability, which contribute to the mobile TOC disbursement goals of Multifunctional On-the-move Survivable Adaptive Integrated Communications (MOSAIC) and enhance on-the-move (OTM) communi-cations capabilities for Future Combat Systems (FCS). These matched filters could be implemented in software resi-dent within an external appliqué. Estimated unit production costs are $200 per radio. The Army's Joint Tactical Ra-dio System (JTRS) managed by Project Manager (PM) JTRS would be targeted to incorporate these capabilities.

PHASE I: Analyze the scattering interference effects occurring over VHF and UHF communications links in the presence of foliage canopies. Provide an analytical proof of concept and design basis for matched filter technologies appropriate for tactical radio systems, in order to mitigate the foliage scattering effects. Develop matched filter designs to improve the signal to noise ratio at the receiver.

PHASE II: Design, fabricate, and integrate matched filters into external applique that can be use with military VHF and UHF tactical radios to demonstrate improve communication in densely foliated regions, signal-to-noise ratio (SNR) at the receiver increased by greater than 20 dB.

PHASE III: The results from this SBIR effort have both military and commercial applications in improving VHF/UHF radio communication operating in jungle and forest. The military often operate in densely foliated areas for con-cealment or in offensive operation to flush out entrenched enemy can greatly benefit from improve communication range and reliability. The FCS and JTRS programs can incorporate these improvements. Communications in the areas of logging and mineral exploration, parks and recreation, search and rescue, and law enforcement, such as drug interdiction, all very often also operate in densely foliated regions which would benefit from improved communica-tions by using the software filters enhancement develop by this SBIR effort.

REFERENCES:
http://www.safco.com/design/design.asp

KEYWORDS: Propagation, modeling, radio, VHF, UHF, matched filter, multipath

A01-118 TITLE: Spectral/Polarimetric Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision

OBJECTIVE: Develop a tactically feasible, passive or active, spectral (hyper or multi-spectral) and/or polarimetric imaging sensor that extends tactical situational awareness capabilities significantly beyond present levels. Emphasis will be placed on sensors operating in the Short Wave Infrared (SWIR), Mid Wave Infrared (MWIR) and/or Long Wave Infrared (LWIR) spectral bands.

DESCRIPTION: Recent investigations of spectral and polarimetric sensing have underscored the benefits of both sensing modalities. Yet most proposed spectral/polarimetric system designs are inappropriate for tactical application because they are too slow or do not sense all of the radiation in a single pixel. Innovative focal plane array concepts or optical designs in the SWIR, MWIR or LWIR bands could solve these problems and provide the basis of simple tactical system designs that improve our ability to cue and ID targets.

PHASE I: Design an innovative sensor which operates in real time, or near real time and has the capability of sensing many spectral and/or polarimetric components in the SWIR, MWIR and/or LWIR spectral bands. Sensing of the different spectral/polarimetric components for a particular pixel in an image should be done as close to simultaneously as possible. The spectral/polarimetric sensing should also, ideally, be spatially coincident.

PHASE II: Fabricate a breadboard imaging sensor which completely demonstrates all of the innovative capabilities of the phase I design. Calibrate the sensor and demonstrate its capabilities in a laboratory setting and finally in a field setting viewing static and moving tactical ground vehicles and helicopters.

PHASE III: The phase III commercialization of this type of sensor includes areas such as environmental monitoring, geological surveying, medical diagnostics, and process control monitoring.

REFERENCES:
J. D. Howe, "Two-color infrared Full-Stokes imaging polarimeter development", Proceedings of the IEEE Aerospace Conference, March 1999.

KEYWORDS: Spectral, Polarimetric, Polarization, Spectropolarimetric Sensing, SWIR, MWIR and LWIR.

A01-119 TITLE: <u>Lightweight mm-Wave Synthetic Aperture Radar/Moving Target Indicator (SAR/MTI) Sensor for Small Unit UAV</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: Develop an innovative lightweight mm-wave SAR/MTI sensor for use on a Small Unit Unmanned Air Vehicle (UAV).

DESCRIPTION: Small/tactical UAVs will play an important role in furnishing timely reconnaissance, surveillance and targeting information to dismounted troops at the platoon level. lThe desired sensor will provide high-resolution SAR imagery and moving ground target detection through smoke, dust, cloud cover, and atmospheric conditions that severely limit the performance of electro-optical/infrared radiation (EO/IR) systems. Although highly desirable, SAR sensors tend to be large and heavy and hence incompatible with small UAVs. Innovative concepts are sought to enable the development of such a SAR/MTI sensor. The desired sensor should have a clear-weather range of 10 km (with graceful degradation in rain), provide high resolution SAR imagery(0.3m or better) and 360 degree MTI coverage, weigh 5-9Kg., and occupy a volume not greater than 0.5 cubic foot. Because of the large bandwidth required, it is expected that a mm-wave design will be necessary.

PHASE I: Develop the lightweight mm-wave SAR/MTI sensor concept and show its feasibility through the design of a flyable prototype assuming state-of-the-art components. Support the design with detailed radar system analysis.

PHASE II: Build and demonstrate the prototype lightweight SAR/MTI sensor for government flight testing.

PHASE III: Small UAVs carrying the lightweight sensor can be used in drug interdiction, law enforcement, and patrolling the borders of the USA.

REFERENCES:
Small Unit UAV Draft ORD, Dismounted Battlespace Battle Lab; USMC Dragon Warrior UAV Concpet Vehicle

KEYWORDS: SAR, MTI, UAV, Radar Imaging, mm-Wave Radar, Surveillance, Reconnaissance, Small Unit Operations, Organic ISR.

A01-120 TITLE: Code Division Multiple Access (CDMA) Repeater for Personal Communications Systems (PCS)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, WARFIGHTER INFORMATION NETWORK-TERRESTRIAL

OBJECTIVE: The primary objective of this research is to study the Code Division Multiple Access(CDMA) repeater for Personal Communications Systems (PCS) Basestation Transceiver Subsystems (BTS) operating at 800Mhz/1900 Mhz band. Development of a repeater will impact the PCS deployment around the Tactical Operation Center (TOC) and greatly expand RF cover-age by filling in gaps between the TOCs. The CDMA Repeater can serve in a number of commercial applications that includes expanding coverage to "dead spot" areas such as suburban areas hidden by terrain and continued coverage inside tunnels. This capability would reduce the need for additional BTS greatly decreasing cost of the tactically deployed systems. Furthermore, this technology product is also the ma-jor element in an airborne repeater or "bent-pipes" being considered for extension of PCS.

DESCRIPTION: PCS has major benefits for secure wireless communications to Brigade and above TOCs, a critical part of the Objective Force for the FCS as will as the Warfighter Information Network - Terrestial (WINT-T) plan for the future BCT. PCS is a revolutionary approach to delivering secure voice and data in a handset, which is included in the Multifunctional on the Move Secure Adaptive Integrated Communication (MOSAIC0 Advanced Technology Demonstration (ATD) strategy. PCS is also the leading candidate for the JTRS wideband handheld waveform. A CDMA repeater will provide range extension for the Warfighter as a coverage capability to enable greater mobil-ity and quick set-up and tear-down of the network infrastructure. Possible end item applications and/or prototype include a low cost CDMA repeater for wireless communications to outlying subscribes between TOCs. Exit criteria for this effort will be providing a repeater to extend BTS range to the subscribes with: 1) Laboratory experiments to characterize the effect of RF coverage, 2) An analysis of the propagation and an examination of different repeater designs to satisfy the special consideration for Army deploy-ment.

PHASE I: Study and recommendations report outlining existing approaches and their limitation with respect to the mobile tactical environment, hardware, and software descriptions with alternative product design, and a plan for integration, en-hancements and implementations required for the specific Army tactical system as discussed above.

PHASE II: The selected design of Phase I will be further developed by completing a specific design plan, fabrication of a prototype and carrying out a demonstration with the specific Army tactical system.

PHASE III: This phase for the CDMA Repeater for PCS can provide enhanced PCS wireless network connectivity and area coverage, particularly in remote areas and/or in difficult terrain and propagation environments. It should result in a significantly lower logistical and manpower burden compared with current PCS base station technology which requires manned operation. Possible applications beyond military communications networks include law enforcement, emergency management, and commercial wireless communications.

REFERENCES:
http://www.cdg.org

KEYWORDS: CDMA, spread spectrum, RF range extension, mobility, quick set-up and tear-down, network

A01-121 TITLE: Readout Integrated Circuits (ROIC) Development for High Performance, Uncooled Imaging Applications

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision

OBJECTIVE: The objective of this activity is to investigate, design and develop a Read-Out Integrated Circuit (ROIC) suitable for high resistivity bolometers. The actual bolometer fabrication is not part of this effort.

DESCRIPTION: The infrared imaging capability of uncooled devices is steadily improving. New materials with potentially very high performance are being developed. To fully realize the potential performance of these materials, it is necessary to re-evaluate the applicable ROIC concepts and technology. The purpose of this activity is to develop and design a ROIC suitable for high resistivity bolometer operating in continuous or close to continuous bias mode.

PHASE I: Investigate, design, and develop a ROIC optimized for high resistivity bolometer operating in continuous or close to continuous bias condition. The bolometer material's properties and parametrics will have some flexibility and will be provide to the contractor by Night Vision Electronic Sensors Directorate (NVESD). The ROIC design shall be optimized for low bolometer detector input (interface) noise, low read noise, high charge handling capacity , and large dynamic range and linearity. Detailed noise modeling of the proposed ROIC design is required. The ROIC design shall be implemented in Complementary Metal Oxide Semiconductor (CMOS) process with moderate design rules. Bolometer performance modeling shall be done in conjunction with NVESD.

PHASE II: Using results of the investigation from phase I, fabricate, build and demonstrate a 320x240 ROIC. Test and characterize the ROIC to compare the theoretical (predicted) noise with the measured noise. Deliver slices, wafers or dies of ROIC circuitry to NVESD for bolometer fabrication and test.

PHASE III: The commercialization of this technology is expected to provide low cost, reliable, high performance uncooled imagers for potential uses in a variety of commercial applications including transportation, security/law enforcement, medical imaging, fire as well as military applications such as night vision, missile seeker sensors, guide munitions, surveillance and target acquisition missions.

REFERENCES:
R.A. Wood, "Monolithic Silicon Microbolometer Arrays," Chapter 3, pp 43-121, Uncooled Infrared Imaging System, Academic Press, San Diego, 1997.

KEYWORDS: Bolometer, Readout Integrated Circuit (ROIC), resistivity

A01-122 TITLE: Flat Panel Speaker Noise Cancellation System (NCS) for Army Communications Shelters

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop an Active Noise Cancellation System to reduce/cancel noise in the interior of an Army communications shelter to acceptable levels without the use of soldier hearing protection through the use of a network of flat panel speakers and state-of-the-art noise cancellation technologies.

DESCRIPTION: Acoustically noisy enclosures, especially Command and Control (C2) Communications Shelters and C2 Vehicles (like the Army's Interim Vehicle, the LAV) present a problem of great importance to Command and Control On-the-Move for Future Combat Systems (FCS). A prime attribute of the FCS is its agility on the battlefield. Whether On-the-Move or stationary, the high ambient acoustic noise levels within these enclosures degrades the ability of the commander to think and act quickly and to communicate clearly. In Network Centric Warfare, this not only reduces the probability of mission success, but endangers the commander and those with whom he is communicating.

When fully equipped, the interiors of communications shelters used on Army vehicles are often extremely noisy. The military requirement for acoustic noise levels in areas like communications shelters which require frequent telephone use or occasional direct communication at distances up to five feet is a maximum speech interference level (SIL) of 65 dB(A). In areas requiring occasional telephone use, such as maintenance shops and garages, the requirement is 75 dB(A) (Reference 1.) Few of The Army's communications shelters meet either of these requirements. This can adversely affect not only the ability of those inside to conduct operational missions smoothly, but can also lead to long-term hearing impairments in some individual soldiers. The noise arises from three principal sources: 1. Fans and generators: These include ECU fans within the shelter as well as rack mounted equipment fans, and electrical generators on the carrier vehicle and/or in the vicinity of the shelter. 2. External sources: These include incidental noise from other vehicles, equipment, and personnel in the area of the shelter, weapon firing and projectile noise, and 3. Vehicular movement: additional noise is generated by the vehicle's power train and the response of the vehicle suspension to terrain, making audible communication difficult during Operations On-The-Move (OOTM).

The R&D challenge of this SBIR is to take two emerging tehnologies- flat panel speakers and active noise cancellation- and integrate them in such a way as to significantly reduce the sound intensity level (SIL) within a C2 communications shelter or C2 vehicle. The effort here is in two parts. First, a tool must be developed that accurately measures and maps sound intensity levels within the shelter. This tool must characterize sound sources, levels and spectral characteristics to provide a sound "map" of the shelter which would then be used as the input into the second part. Second, an active noise cancellation/reduction system that would dynamically take the information from the sound "map" of the shelter and attenuate the actual sound levels sufficiently- 65 dB(A) or lower- to permit normal conversational levels to be used by personnel in the shelter.

The development of flat panel speakers represents an advance in audio technology that may make active noise cancellation inside a cramped shelter highly feasible. Combined with the use of appropriate microphones and acoustic signal processing, flat panel speakers could be placed in a number of locations throughout the shelter---taking up little volume---and significantly reduce ambient noise levels within the shelter. This will enhance the agility and survivability of the Objective Force by allowing dialog on an active battlefield.

PHASE I: The contractor shall design a flat panel speaker based noise cancellation system architecture as described above for Army communications shelters. The contractor shall then perform a feasibility analysis of the design and demonstrate its attributes through analysis, simulation, or other means. As a minimum, this analysis shall include: technology issues, operational issues (including Electromagnetic Interference-EMI), power requirements, size and weight issues. The contractor shall also develop a test plan during Phase I that will enable comprehensive testing of the devices during Phase II.

PHASE II: The contractor shall prototype the flat panel speaker based noise cancellation system per the proposed Phase I system design. The contractor shall install the system in a contractor furnished standard Army communications shelter containing racks and surrogate/actual representative noise sources and sufficient measurement equipment to determine that requirements have been met. The system will be tested per the proposed Phase I test plan in Government approved configurations.

PHASE III: Commercially, an active noise cancellation system such as will be developed under this SBIR, will have applications in existing noise sensitive environments such as aircraft, automobile, truck, farm equipment, rail, space and industrial operations. Potential military applications include tank and other armored vehicles, ship, submarine, helicopter and fixed wing aircraft.

REFERENCES:
MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, par. 5.8.3.

KEYWORDS: acoustic, noise cancellation, flat panel, shelter, Operations On-The-Move (OOTM)

A01-123 TITLE: Miniaturized Preselector/Notch Filters for ES Payloads

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet, LTC Stevenson/PM Signals Warfare

OBJECTIVE: Design and build miniaturized preselectors and/or notch filters for use as components within electronic support (ES) receivers. The preselectors and/or notch filters will provide a high degree of isolation from large, out-of-band RF interference signals, without significant reduction in sensitivity to in-band signals-of-interest (SOIs).

DESCRIPTION: The goal of an ES receiver is the intercept, detection, and processing of RF SOIs, typically in the presence of a large amount of RF interference and signals-not-of-interest (SNOIs). This function is particularly challenging in the VHF and UHF frequency bands where large numbers of commercial television stations broadcast at power levels several orders of magnitude larger than typical SOIs. It is common practice for the control system of an ES receiver to set the receiver gain in response to the largest in-band signal. The amount of gain applied, in conjunction with the receiver dynamic range and some other factors, in turn determines the system sensitivity. As a result, when a high power emitter falls within the ES receiver search bandwidth, the applied gain and hence the system sensitivity tends to be reduced. This problem can be resolved in part by a combination of preselector filters (and tuning of the receiver in order to place the large signal outside the preselector bandwidth) and/or notch filters (which would selectively excise the SNOIs). To date, these approaches are limited for a variety of reasons. First, the ES system requires a greater degree of center frequency and bandwidth agility than is currently available with standard filter implementations. This can be addressed in part by using banks of filters, but the requisite size, weight, power, cost, and complexity are far too great for Army applications. Second, the insertion loss of current generation notch filters is higher than desired. This severely limits the potential improvements in sensitivity derived from using notch filters. In order to meet the ES receiver requirements, an innovative solution is sought that will provide a miniaturized preselector and/or notch filter module or RF integrated circuit (IC) whose size, weight, power, cost, and complexity are consistent with its use as a component within an ES receiver, and whose insertion loss is sufficiently low as to not limit its application.

PHASE I: Design a preselector and/or notch filter module or RF IC capable of selectively obviating the effects of VHF and UHF commercial television transmitters. Model the design using commercially available tools, and develop a set of specifications for the module.

PHASE II: Develop and demonstrate a prototype of the preselector and/or filter module or RF IC. Conduct testing to validate the electrical perfomance of the prototype.

PHASE III: This technology will have direct application to the growing market for multi-standard commercial wireless equipment (telephones, pagers, wireless Internet, etc.).

REFERENCES:

A wealth of information on RF filter technologies is available in the Proceedings of the IEEE International Frequency Control Symposium, Proceedings of the IEEE International Ultrasonics Symposium, and in the IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control. These may be located via the IEEE UFFC website www.ieee-uffc.org

KEYWORDS: filters, preselectors, notch filters, electronic support

A01-124 TITLE: Automated Network Aware Applications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The commander's critical information requirements (CCIR) requires the battle command system deliver extremely, time-sensitive information (e.g. voice, data and video) at the right place and at the right time for the few key decisions he/she will make on the battlefield. The commander's critical information, therefore, must be supported by whatever the immediate means available to the commander including mobile (e.g., wireline and wireless) communications.

The objective is to utilize network and communications-provided information in order to adaptively and independently automate, control and scale the information and signaling flows thereby maintaining the quality of voice, data and video applications using "state-of-the-art" microprocessor technology. New automated network aware applications utilizing "state-of-the-art" micro-processor technology in conjunction with network and communication protocols are required within the new communications systems being developed. They are needed to automatically and systematically control and maintain, and in real-time, the individual information and signaling flows caused by environmentally induced variations characterized by sporadic connectivity and varying quality in the networking and communications link, thereby maintaining the required quality of voice, data and video applications.

DESCRIPTION: Quality is a very subjective quantity to analyze no less to design for. Effective and useable network and communication-provided information is currently not being utilized to maintain the quality of voice, data and video applications caused by environmentally induced variations in a given network and communication link. The goal of an automated quality measurement and control system is to provide a single solution that completely describes the required quality of the voice, data and video application. With regard to speech, as an example, subjective performance measures are designed to provide a measure of how the speech is perceived by a subscriber. Several subjective measurement techniques are employed for speech to address the quality of synthesized speech. These include diagnostic rhyme test (DRT), diagnostic accept-ability measure (DAM), and mean opinion score (MOS). The DRT is an intelligibility test where the listener tries to recognize a pair of rhyming words such as meat/heat. The DAM is an acceptability of speech test designed to measure the quality of a system. The MOS test is designed to quantify the quality of coded speech.

Microprocessor controlled network aware application protocols are required to provide network information automatically, thereby controlling self-initializing and self-healing for adaptive networking and communication link to scale an adaptive video/voice applications from 30 frames per second with audio-to-10 frames per second and with audio-to-audio only. Voice and video quality should meet Rhyme testing greater than 90%, Latency less than 250 msec, Delay Jitter less than 150 msec, and Bit error rate less than 10-4. Microprocessors may provide a lower cost solution, lower power consumption and more flexibility than other processors. As the demand for both high quality and integrated low- medium- and high-bit rate systems increase, the de-signer may be forced to use more sophisticated network aware application protocols. This implies larger, more computation-intensive algorithms with longer encoding and decoding delays. Microprocessor controlled network aware application/protocol(s) may be required to provide consistent quality to time sensitive applications, thereby, providing useable information to the Warfighter.

The program output is a microprocessor-controlled network aware application/ protocol(s) de-sign required to automatically and efficiently measure and scale the per flow metrics, and therefore, in real-time, control the quality of voice, data and video applications. The per flow metrics (e.g., OSI layer) must be adaptively and independently automated, controlled and scaled using "state-of-the-art" measuring techniques in order to determine the appropriate balance between the level of speech, data and video flow degradation that can be tolerated while still maintaining communications to the Warfighter. Trade-offs need to be performed between quality and the required bit rate, coder complexity, etc. The trade-offs, therefore, must consider the quality versus bit rate, coder complexity, etc. limitations imposed by the networking and communications system. The trade-offs must also consider the per flow metric measurements and benchmarking in terms of communication service availablity, throughput,

latency, jitter, packet loss, packet sequence, connection availablity, etc., versus the required memory, the operating speed, printed circuit board area, and power consumption the network aware application protocol(s) must provide, and most importantly, and the cost that the networking and communications system must absorb. Unfortunately, there may not be single solution that can satisfy all the requirements related to design, development and implementation of network aware application protocol(s). However, cost often influences the possible solutions to problem. A single solution, if possible, would be meaningful and reliable if it was acceptable across all networking and communications systems and network aware application protocol(s). This, however, may not be the case.

PHASE I: Research, trade-off and design a prototype microprocessor-based Automated Network Aware Applications platform capable of automatically and efficiently scaling, and therefore, in real-time, control the flows, and therefore, the quality of voice, data and video applications required to support delivery of battle command and simulation applications or found commercially. Phase I addresses networking and communications systems and includes the required design documentation.

PHASE II: Develop, test, integrate and demonstrate the microprocessor-based Automated Network Aware Applications platform capable of automatically and efficiently scaling, and therefore, in real-time, control the flows, and therefore, the quality of voice, data and video applications required to support delivery of battle command and simulation applications or found commercially. Demonstration will first be perfomed at the contractors plant and then at a Government installation (e.g., CECOM).

PHASE III: Dual-Use Commercializers (Real-world Examples): The Phase III microprocessor-based Automated Network Aware Applications platform will bring advanced technology to military networking and communications in order to deliver quality commander's critical information. The primary military application is developing advanced network aware technology for network-centric communications directly to the military commander's real-time multimedia products used in the delivery of his/her critical information. The primary commercial application will bring new quality of service (QoS) technologies offering the opportunity of network equipment manufacturers to develop new products, network service providers to offer value-added services and enterprises to upgrade their networks to support QoS enabled networking for the delay-sensitive nature of voice and multimedia. QoS enabled networking for both military and commercial applications requires advanced network aware technology in order to cost effectively and respond rapidly to changing requirements such as virtual private networking, voice over IP, multimedia, and electronic commerce resulting in huge demands for new bandwidth and more efficient ways to use it.

REFERENCES:
1) Battle Command Handbook found on the WWW Site: http://cacfs.army.mil/index1.htm.)
2) Joint Tactical Architecture (JTA) available at http://www.jta.itsi.disa.mil/jta/jtav3-final-19991115/finalv3.html

KEYWORDS: Battle Command, Agile Commander, IETF, Quality of Service (QoS), Warfighters Information Network (WIN), Wide Area Network (WAN), Intranet, Internet, Mobile IP, Applications, Simulations

A01-125 TITLE: Template Generation From A Small Number of Views

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision

OBJECTIVE: To develop a system for creating, from a short series of images of an object, images of that object from prescribed alternative viewpoints and to use that system for the recognition of known targets and the cataloguing of unknown targets.

DESCRIPTION: Within the last ten years, the development and systemization of techniques in multi-view geometry have led to radical improvements in the ability to concisely encode the projective geometric relations between objects in images taken by cameras at disparate angles, translations, and focal lengths. It is even possible to generate novel views from as little as two images that are not interpolations between the two camera shots. However, the projective geometric nature of this encoding makes useful transitions to Euclidean space (and thus applicable metric evaluations) problematic. Also, the methods require a dense correspondence of points between two images, which must be achieved in the field without prior knowledge of the objects being imaged.

PHASE I: Utilize and enhance existing optical flow algorithms (or create new such algorithms) to develop reliable techniques for establishing the necessary point correspondence between two photographs taken by an aerial sensor or some other surveillance device. Develop camera auto-calibration techniques to overcome the difficulties imposed by projective multi-view relations and transfer these relations into metric ones, i.e., be able to produce from two or three views of an object, novel views at specified angles and distances.

PHASE II: Design, build, and demonstrate software associated to a sensing device capable, when overflying or otherwise encountering a potential target, taking a series of photographs of the target, matching that target to a database constructed of a limited number of photographs of established targets. Moreover, if the new target does not match any of the existing ones, making a new reference in the database. In short, creating a precise translation between uncalibrated, projective conditions and metric (Euclidean) ones is essential and must be done both in the image registering and image matching phases of the operation.

PHASE III: Commercialization of the technology would involve any situation where, a newly introduced object must be either recognized or catalogued from a small sequence of images, perhaps of unknown distance or from unknown camera conditions. This would include automated surveillance devices of all kinds, and would also be applicable to automatic navigation systems.

REFERENCES:
1) S. Avidan and A. Shashua, "Novel View Synthesis by Cascading Trilinear Tensors", IEEE Trans. On Visualization and Computer Graphics, vol. 4, no. 4, Oct.-Dec. 1998.
2) M. Pollefeys, et al., "Three-dimensional Scene Reconstruction from Images", SPIE Electronic Imaging 2000, Three-Dimensional Image Capture and Applications III.

KEYWORDS: Trifocal or Trilinear Tensor, Fundamental Matrix, Camera Self-calibration.

A01-126 TITLE: Miniaturized Low Jitter Clock for Digital Receivers

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PM Signals Warfare

OBJECTIVE: Design and build a miniaturized low jitter clock oscillator suitable for board-level integration in a 6U-VME form factor digital receiver. The clock jitter must remain sufficiently low as to not degrade the digital receiver performance over extremes of environmental vibration, temperature, and pressure changes, and variations in electical supply voltages.

DESCRIPTION: Army requirements for electronic support (ES) necessitate the use of intercept receivers with extremely broad instantaneous bandwidth (on the order of several hundreds of Megahertz). However, this broad bandwidth inevitably results in both very large (up to megawatt ERP) and very small amplitude (on the order of milliwatt ERP) signals appearing simultaneously in the receiver bandwidth. Properly handling both signals simultanously requires on the order of one hundred dB of two-tone spur-free dynamic range. This level of dynamic range has been demonstrated in bench tests of a prototype digital receiver. However, it also has been shown that the dynamic range is limited by the clock jitter. This is particularly significant when considering Army applications such as the Tactical Unmanned Aerial Vehicle (TUAV) Signals Intelligence (SIGINT) Payload. Whereas the clock used for bench tests is a 19" rack-mountable cryo-cooled sapphire DRO, the clock for the 6U-VME version of the digital receiver cannot exceed a 0.2" x 0.2" x 0.5" DIP package space allocation. While some effort has been expended by DARPA to develop a suitable clock oscillator, it remains beyond the current state of technology to produce an oscillator capable of providing the required low jitter in such a small form factor. Further, it also remains a challenge to maintain the low jitter performance over extremes of environmental vibration, temperature, and pressure changes, and variations in electical supply voltages. In order to meet the ES requirements, an innovative solution is sought that will provide a miniaturized low jitter clock suitable for board-level integration in a 6U-VME form factor digital receiver, whose jitter will remain sufficiently low as to not degrade the digital receiver performance over extremes of environmental variations.

PHASE I: Design a miniaturized low jitter clock oscillator suitable for board-level integration in a 6U-VME form factor digital receiver. Through suitable engineering analysis, modeling and simulation, demonstrate that the proposed design should yield clock jitter sufficiently low as to not degrade the digital receiver performance over extremes of environmental vibration, temperature, and pressure changes, and variations in electical supply voltages.

PHASE II: Build multiple clock oscillator prototypes. Characterize performance over extremes of environmental vibration, temperature, and pressure changes, and variations in electical supply voltages.

PHASE III: This technology will have direct application to ruggedized enhanced precision GPS receivers.

REFERENCES:
A wealth of information on clock oscillators, phase noise, environmental effects, etc. is available in the Proceedings of the IEEE International Frequency Control Symposium and in the IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control. These may be located via the IEEE UFFC website www.ieee-uffc.org

KEYWORDS: clock, oscillator, digital receiver, electronic support

A01-127 TITLE: Image Compression and Transfer Over High Frequency Radio

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, AVIATION ELECTRONIC COMBAT, PEO Aviation

OBJECTIVE: Transmit visual information from aircraft back to the Technical Operations Center (TOC) over a High Frequency(HF) radio circuit in under one minute, to include sending initial image in thirty seconds at a data rate of 2400 bps from start of transmission.

DESCRIPTION: Transmit an image over a HF radio circuit in thirty seconds at a data rate of 2400 bps. Send subsequent images (slow video) at least once every three seconds. Prepare image for transfer over a 2400 and 1200 bps high frequency radio channel and allow for subsequent images (slow video) via updating the video portions that have been changed since the last image. Limiting of colors transmitted could reduce file size. Emphasis is primarily on transfer and clarity is considered secondary.

PHASE I: Perform an analysis of the proposed image compression techniques(s) and submit as a report. Cover existing commercial image capture and compression techniques to include Joint Photographic Experts Group(JPG) image formats. Analysis should include how redundancy in an image can be identified and techniques for reducing image size and maximizing transmission throughput. Report should include comaprative methods for testing.

PHASE II: Submit prototype software that executes proposed software algorithm for use on a PC and demonstrate to the Government. Contractor will start by using a standard JPG image over an actual Government HF radio. Subsequent tests will be performed using the algorithm. Submita test plan 60 days prior to the start of the test and a test report 60 days after the conclusion of the test. The report must quantitatively include how transmission time of the HF radio was reduced.

PHASE III: Military Application: Any long-range military communications required wherein images, graphics, or pictures must be transmitted. Examples are Medevac, Scouts, Military Intelligence, Special Operations, Federal Law Enforcement Agency plus aircraft to TOC operations.
Commercial application: Emergency service personnel, law enforcement personnel. HF is normally a secondary system for long range communication and becomes primary as a result of as a result of commercial disruption.

REFERENCES:
http://www.usarmyaviation.com/threat.htm and High Frequency Nap-of-the-Earth Communications, Tactics, Techniques and Procedures; April 10, 2000.

KEYWORDS: High Frequency radio, image, compression, slow video.

A01-128 TITLE: Robotic Mine Detection Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Mines, Countermine & Demolitions

OBJECTIVE: Develop lightweight, low-power mine detection sensors for deployment on robotic platforms, and the sensor data interfaces, data fusion and control logic to support multiple robot deployment.

DESCRIPTION: The U.S. Army has developed mine detection sensors such as ground-penetrating radar and metal detectors for use in hand-held mine detection systems. To remove soldiers from direct exposure to threats in this process, there is a need to deploy sensor technologies in clearance missions. Currently, soldiers operate the Handheld Standoff Mine Detection System (HSTAMIDS) with little distance between the soldier and the threat. This is a very stressful task for the soldier and there is no room for error.

The goal is to miniaturize mine detection sensors proven effective for handheld detectors, make them functional on robots and operate the robot with a remote user interface, or control system. This requires integration of sensor data fusion, mine detection algorithms and automatic mine declarations in the control system, to facilitate soldier access to sensor system performance and declaration related data.

Typically, dismounted soldiers clear a 1-m wide path. Depending on how successful the miniaturization effort is, several robots/sensor systems may be required to search the 1-m wide or wider (with overlaps) path. If multiple robots are employed

control logic must include logic for synchronized navigation. The robots must remain small, inexpensive and expendable, hence the need for highly efficient data transfer protocols and power-efficient sensor systems to minimize robot power demands. Commands to activate a marking system are implied. Initially, the robotic detection capability must be highly effective on roads and trails. Subsequent efforts would extend to off-route environments.

Robots are being developed under other programs such as the Basic Unexploded Ordnance Gathering System (BUGS) sponsored by the Defense Advanced Research Projects Agency (DARPA) Joint Robotics Program,Tactical Mobile Robots Program and Distributed Robotics Program. This work will develop miniaturized mine detection sensor systems, interface and control logic and sensor data fusion algorithms and demonstrate the ability to deploy them on robots, achieving remote detection with existing robots.

PHASE I: This Phase shall include design and definition of a configuration to integrate one or more miniaturized sensors with electronics and power source, remote data transfer, remote sensor data fusion on the control system and graphical user interface to control robot motion in concert with the mission and other robots. Interface with a geographic information system and/or differential Global Positioning System may be required. Demonstration of effective operation will conclude Phase I.

PHASE II: Following physical assembly of the successful Phase I design, a full-scale demonstration will be conducted with up to three robots to determine performance of buried mine detection, sensor data fusion, and navigation. Fine-tuning of the system should be conducted in this Phase.

PHASE III: Given a successful Phase II effort and a private-sector sponsor, the design developed in Phase II will be configured and marketed as a commercial product for the solution of this and similar problems. The resulting system must be capable of supporting a live-fire demonstration where the system is operated by U.S. Army soldiers. Buried mine detection via robotic sensors has many commercial applications in humanitarian demining, military, environmental range remediation/active range clearance and police/explosive ordnance disposal (EOD). The benefits to these mission areas are as follows: Demining¾reduces obvious hazards to, and speed progress of deminers to locate mined areas. Military¾augment dismounted sweep teams with a small, expendable standoff detection platforms, reduce stress/fatigue and increase speed of operations. Environmental remediation/range clearance¾Cover large tracts of land to detect buried ordnance cost-effectively. Police/EOD¾send robots into booby-trapped buildings or settings where explosive devices have been deliberately secreted from view, making the use of sensor suites necessary.

REFERENCES:
Web sites that provide information on countermine, environmental range remediation, active range clearance, demining and explosive ordnance disposal include the following: www.uxocoe.brtrc.com; www.usmc-awt.brtrc.com. Descriptions of on-going robotics program may be found in the Defense Research Projects Agency (DARPA) Joint Robotics Program Master Plan

KEYWORDS: Landmine Detection Sensors, Sensor Data Fusion, Automatic Target Recognition, Robots and Robotics, Control Algorithms, Navigation, Detection and Countermeasures,

A01-129 TITLE: Telemaintenance of Future Combat System (FCS) Semi-Autonomous Platforms and Equipment

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Design and build a telemaintenance capability that will enable the Future Combat System (FCS) platforms to attain a state of high readiness through both semi-autonomous preventative measures and maintainer intervention.

DESCRIPTION: The Army's FCS enabled force will require platforms and equipment capable of functioning without a large support operation. These platforms and supporting items must maintain a high level of readiness because replacement systems and support personnel are not envisioned as being part of the initial deployment in times of crisis. Current advances in communications have paved the way for a robust telemaintenance capability. However, current command and control (C2) systems and networks are not designed to provide a telemaintenance capability. (In the past, NASA engineers have reprogrammed systems when maintenance actions were required This effort would examine the use of information technology to explore the potential of autonomous and semi-autonomous maintenance of a remote air/land/ground platforms and electronic items. In cases where the item/platform requires human physical intervention, this effort would demonstrate the ability of a maintainer to collaborate with a remote subject matter expert. This telemaintenance capability will greatly increase the Objective Force's sustainability by virtue of rapid access to maintenance expertise, documentation and data and deployability by obviating the need for an extensive maintenance support infrastructure. Thus the FCS will have enhanced responsiveness of its platforms. This proposal supports the Logistics Command and Control (Log C2) Advanced Technology Demonstration (ATD).

PHASE I: Develop overall system design that includes specification of existing communications technology applied to solving new command and control management of maintenance information. System specification will include an analysis of measures that can be either autonomously or semi-autonomously implemented that will extend service life or heighten readiness. Additionally, information gathering needs will be assessed for repair personnel that must interact with subject matter experts via a Telemaintenance system.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III: This system could be used in a broad range of military and civilian applications where items require maintenance of high value items in remote areas. Currently companies are investing in this technology for everything from airplanes to elevators.

REFERENCES:

1) http://www.cascom.lee.army.mil/cssbl/
2) http://www.cascom.lee.army.mil/cssbl/army_after_next/index.htm
3) http://www.cascom.lee.army.mil/cssbl/Fcs/Index.cfm
4) http://www.arpa.mil/fcs/links.html
5) http://www.cascom.lee.army.mil/cssbl/download.cfm
6) http://armyhti.redstone.army.mil/
7) http://www.lee.army.mil/csscs/
8) http://www.lee.army.mil/csscs/logistics_in_gccs-a.htm
9) http://www.lee.army.mil/csscs/fbcb2.htm
10) http://www.lee.army.mil/csscs/Interoperability/interop.htm
11) http://160.147.21.82/wsdocs/stccs/gccsa.htm
12)http://www.darpa.mil/fcs/public.html
13) http://www.darpa.mil/fcs/index.html

KEYWORDS: Telemaintenance, logistics, command and control, communications

A01-130 TITLE: Fiber Optic Dynamic Strain Sensors for Seismic Monitoring

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Prophet

OBJECTIVE: Develop a new technology for seismic sensors that are very small, highly sensitive and immune to electromagnetic interference (EMI) plus a sophisticated computer based real time data acquisition, processing and analysis system.

DESCRIPTION: Fiber optic sensors, especially fiber Bragg grating (FBG) 1,2 based sensors have found a wide range of applications due to their unique properties. A number of sensing concepts have been proposed and demonstrated. Most of these sensors are configured as back reflectors. A more general configuration, a Tapped Bragg Grating (TBG), was also demonstrated. Bragg gratings have several advantages over other types of fiber optic sensors. The main advantage is that several Bragg grating sensors can be placed in a single fiber optic line and be independently addressed. FBG¡¦s are also immune to electromagnetic interference (EMI), and the output of the BG is absolute, (it has a built in reference length scale, the Bragg Period, relative to which strains are measured) and FBG sensors are very small (a bare fiber is 125 ƒÝm in diameter and most fiber Bragg gratings are about 1 cm long) allowing them to be placed in small places or even embedded within composite materials, while traditional strain sensors are bulky. As a result, Bragg gratings are currently being considered for smart material applications, where an entire panel is interrogated with a single fiber. The physical quantity that a Bragg grating measures is strain. The output readout from this device is linear and absolute. The strain sensitivity can be better than 10-2 ƒÝƒnstrain while the maximum value is defined by the fiber limit. Other types of fiber optic sensors exist, such as the Fiber Fabry-Perot (FFP) interferometer, Tapped Bragg Gratings (TBG), and Bi-Conical Tapered (BCT) Fibers. Each type of sensor has its advantages and is finding new military and commercial uses. Before implementation into military and civilian applications, such as airplane structural health monitoring, seismic monitoring, these fiber sensors must be tested for durability and reliability in the hostile environment. For example, one must ascertain the survivability of fibers under fatigue and other harsh environmental conditions. Fiber gratings are ideal for multiple-sensor applications as many of these gratings can be employed either in series or in parallel. In this aspect, many of the multiplexing technologies developed in the telecommunication industry can be directly applied. These include time division multiplexing and wavelength division multiplexing. Thus, it is reasonable to envision in the near future of deploying hundreds of fiber Bragg gratings on in a given area to continuously monitor seismic activities of either natural or unnatural origin. To be sure, there is a multitude of technical challenges that must be overcome to make this a reality. First, the detection

sensitivity must be very high. This is especially important since seismic events are usually buried in a noisy environment. Secondly, detection speed must be high enough to capture instantaneously most of the frequency contents of a signal. Thirdly, one must develop a sophisticated computer-based real-time data acquisition, processing, and analysis system in order for the sensors to be truly effective. These challenges must be overcome through systematic experimentation in conjunction with simulation and modeling. It is promising that an experimental program of using optical fiber Bragg gratings to detect dynamic, seismic signals can be fruitful. As is well known, troop and vehicle movement will induce ground vibrations, which constitute weak seismic signals. If such signals can be detected accurately, in a remote and real-time mode, it will greatly aid intelligent gathering, battlefield monitoring, and battle planning.

PHASE I: To assess the feasibility of using FBG¡¦s to monitor weak seismic activities. Demonstrate single-sensor in a laboratory environment.

PHASE II: Develop and demonstrate multiple sensors for remote and real-time monitoring of weak seismic activities in the field.

PHASE III: Develop a production type prototype for development of tactics and doctrine and incorporation of this technology into the Prophet Block IV program and INSCOM capabilities. Dual use as sensor in commercial security systems and manufacturing. In particular, the fiber optic sensor may have application in explosive atmosphere manufacturing areas. This program also has definite potential for a dual use program in the mining industry and telecommunications industry.

REFERENCES:
1) K.O. Hill, Y. Fujii, D.C. Johnson, and B.S. Kawasaki, App. Phys. Lett., 32, 647 (1978).
2) G. Meltz, W.W. Morey, and W.H. Glenn, Opt. Lett. 14, 823 (1989).
3) G. Meltz, W.W. Morey, and J.R. Dumphy, SPIE 1587, 350 (1991).

KEYWORDS: sensors, EMI

A01-131 TITLE: Wireless Communications-Coverage Software (WC2S)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Warfighter Information Network - Terrestrial

OBJECTIVE: The primary objective of this research is to develop Wireless Communications-Coverage Software (WC2S) to permit on the ground prediction of wireless communications systems coverage, particularly Personal Communication System (PCS). PCS has major benefits for secure wireless communications to Brigade and above Tactical Operations Centers (TOCs), a critical part of the Objective Force for Future Combat Systems (FCS) as well as the Warfighter Information Network - Terrestial (WIN-T) plan for the future Brigade Combat Team (BCT). PCS is a revolutionary approach to delivering secure voice and data in a handset, which is included in the Multifunctional on the Move Secure Integrated Communication (MOSAIC) Advanced Technology Demonstration (ATD) strategy. PCS is the leading candidate for the Joint Tactical Radio System (JTRS) wide band handheld waveform. WC2S is relevant to battlefield commanders and coordinators be-cause it ensures situational awareness for the Warfighter by providing reliable coverage information for PCS and other wireless communications networks. Current predicitions in the commercial area are based on generalized predictions. This program will derive more accurate predictions based on the location environment(hills, foliage, buildings) and represent the findings on computer generated graphics.

DESCRIPTION: WC2S consists of a graphical user interface (GUI) that is user friendly and visually provides comprehensive coverage information to the user. The coverage prediction provided will be based on nu-merous variables that effect propagation potentially including terrain, foliage, and urban environments. WC2S will predict coverage for a variety of wireless system parameters and, in order to assure accuracy, will be based on appropriate mathematical theories in radio frequency (RF) propagation. The user of WC2S will "place", via the GUI, wireless communications equipment on a digital map of the battlefield environment and be pro-vided with an accurate visual prediction of communications coverage.

PHASE I: Study available approaches and recommend applicabile propagation theory, graphic vehicle and computer implementation. Provide examples of potential approach solution.

PHASE II: Design, develop, and demonstrate WC2S as applied to identified Army applications of PCS technology. Perform validation testing of the software propagation and planning modeling approaches identified in Phase I. Develop a complete hardware and software system to provide the viability of producing a network planning product for use in the widest variety of geographical and environmental conditions in both military and commercial applications.

PHASE III: Militarily, this capability provides a network planning tool for the personal communications networks. Applications include tactical military networks.

Commercially, this capability can be utilized by law enforcement agencies, emergency management agencies and commercial networks of a temporary nature, eg. sports events and augmentation of existing capabilities.

REFERENCES:

http://www.safco.com/design/design.asp

KEYWORDS: RF propagation and predictions, PCS coverage and planning tool, network design and analysis, wireless measurement tools

A01-132 TITLE: Variable F-Number (F/#) Cold Shield Aperture

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision, Close Combat Systems

OBJECTIVE: Develop a means by which a sensor with a cryogenically cooled focal plane detector can provide multiple F# operation for optimal adaptation of the aperture-constrained sensor to the viewing conditions.

DESCRIPTION: To maximize sensitivity and reduce the effects of stray light within an infrared sensor, it is common practice to place a system aperture stop inside the cryogenically cooled Dewar near the focal plane array (FPA). This is often referred to as a "cold shield" or "cold stop", and it serves to hold the sensor optics to a fixed F/# value by defining the conic angle of convergence as light is focused onto the FPA. Thus, the F/# remains the same even if multiple fields of view are selectable in the forward optics.

Focal plane irradiance, a critical parameter in determining a sensor's overall sensitivity, is proportional to the square of the F/#. For example, a sensor at F/2.12 has twice as much irradiance as one at F/3. In terms of aperture entrance pupil diameter (EPD) and effective focal length (EFL), the F/# is defined loosely by F/# = EFL/EPD. Many military platforms have restrictions on the maximum aperture size that can be carried, which, for a fixed F/#, will also put a maximum limit on sensor focal length. This in turn limits the sensors maximum resolution.

In military environments, where aperture sizes are limited due to platform requirements, and depending upon the user's task, it is not often that a single F/# is optimal for any given FPA under varying conditions. Therefore, the system developers attempt to find the best compromise for the actual cold shield dimension. A more optimal condition would be if the optical system could provide at least two F/# stop diameters, one for the case when sensitivity is at a premium, the other for situations when sensitivity is secondary to the long resolution offered by a long focal length. Such a device would be directly applicable to a program such as Multi-Function Staring Sensor Suite (MFS3).

Possible dual use applications include space/astronomy applications and paramilitary applications such as search and rescue, border patrol and surveilllance.

PHASE I: Development and demonstration of a variable cold shield aperture for operation at a minimum of two different F/#'s, based on a given system back focal length (BFL). The system must be able to support a change in F/# of at least F/4.5 to F/6.7 (based on a BFL of 2.0"). The cold shield must be operable at 77K (temperature inside of a dewar), but integration into a dewar assembly is not required. The goal is to obtain >98% cold shield efficiency at two different F/#'s. The following should be considered and addressed in proposals: 1) adverse effects on FPA (eg. magnetic fields, electrical fields, etc.), 2) transmission function across aperture 3) size of assembly, 4) power required, 5) repeatability of aperture sizes, and 6) feasibility of being integrated into a dewar assembly. Advantages will be given to proposed designs that have a constant variable F/# (more than two aperture sizes), and that exceed the given range in F/#.

PHASE II: Integration of a variable cold shield aperture into an operating dewar assembly. This concept incorporates a variable aperture that can survive repeated temperature cycling from the near 77K typical Dewar temperature to room and storage temperatures of 45 C. The assembly should achieve as close to 100% cold shield efficiency as possible, and be integral to the Dewar, such that any arbitrary optical system designed for the proper back focal length and range of F/#'s needs no further modification. The aperture requirements are the same as in Phase I.

PHASE III: Commercialization of the variable cold shield into a viable option for use in production programs. Possible dual use applications include space/astronomy applications and paramilitary applications such as search and rescue, border patrol, and surveillance.

REFERENCES:

1) US Army NVESD Multi-Function Staring Sensor Suite (MFS3) ATD
2) Fundamental of Infra-Red Detector Operation and Testing, Vincent, c. 1990, Wiley & Sons.

KEYWORDSs: Cold shield, cold stop, Dewar, F/#, optics

A01-133 TITLE: Stability And Support Operations (SASO) Game Theoretic Knowledge Acquisition Tool

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, INTELLIGENCE, ELECTRONIC WARFARE AND SENSORS

OBJECTIVE: To develop a knowledge acquisition tool using applied game theory that will enable military planners to understand the context and significance of a unit operating within a SASO environment. This tool will simultaneously enable the computer to better "understand" the operational implications of decisions by the unit commander and staff planners.

BACKGROUND: A well crafted computer game can assist military planners in their tactical decision-making, particularly with respect to quickly identifying responses and counter-responses to enemy action or inaction. Unit commanders would apply such a game theoretic tool in order to determine the best allocation of tactical resources to accomplish the unit mission and satisfy the commander's intent. When the staff use a suitably automated "wargaming" tool to support Course of Action (COA) Analysis, the unit commander can quickly gain a comprehensive understanding of the action-counteraction dynamic between the opposing units (actors).

This understanding becomes particularly important for identifying and prioritizing "gaps" in a unit's knowledge about enemy disposition and intent since collection assets can be concentrated on enemy indicators that "tell" or "give away" tactically significant actions. This understanding can also greatly assist in the analysis of uncertain intelligence by reducing the probability of tactically "stupid" enemy actions and increasing the probability assigned to savvy opposition moves.

A good example of such a "Course of Action Wargaming" tool is the FOX Genetic Algorithm (see reference section). Unfortunately, FOX and most every other COA decision support tool assume the unit to be operating in a conventional war rather than a SASO environment (World War II instead of Bosnia); these wargaming tools need to evolve to "peace-gaming" decision support tools.

A difficult challenge for SASO gaming system development is that the system designer must strike an appropriate balance between representing pertinent game aspects while abstracting away irrelevant detail in order to achieve the efficiencies required to appropriately sample the action-reaction game space. In other words, we can't have a computer model that is so detailed that it can only game a few scenarios when thousands of scenarios may need to be sampled. Likewise, the game must be designed in sufficient detail to provide useful insight to the allocation of resources.

In order to strike this balance between detail and abstraction the game designer must have an extraordinary understanding of the SASO METT-TP (Mission, Enemy, Troops, Terrain, Time, and Politics) circumstances. Unfortunately, this dynamic is so context-dependent that units typically do not learn the "SASO rules" until they are already deployed to the mission. Current research in this field indicates that the best solution to this dilemma is to develop a simple knowledge acquisition system that enables the military analysts to quickly encode SASO game rules into a decision support wargaming system after already having deployed to the mission site. The unit personnel must be able to do this without assistance of expensive contracting to civilian knowledge engineers and scientists.

In summary, unit staffs are in dire need of a game theoretic decision support tool for SASO missions, but this can only be reliably built for future missions if the Knowledge Acquisition component of the system is powerful enough for military analysts to enter contextual domain knowledge after mission deployment.

DESCRIPTION: The objective system will enable military analysts and planners within a unit to enter directly into a game theoretic decision support tool SASO domain knowledge such as entities and agent-based rules about entity interaction. They must be able to do this quickly and simply after having already deployed to the SASO mission, and they must be able to do it without the support from engineers or scientists conducting knowledge elicitation and acquisition. The decision support tool that

receives the new domain knowledge must be able to provide comprehensive insight to the action/reaction dynamic between the deployed unit and potential adversaries with respect to the employment of resources such as collection assets. It would be desirable, but not necessary, to have a system with supporting visualization services such as game animation at the symbolic level.

PHASE I: Conduct a technical feasibility study, identify the scope and general approach for a prototype system, investigate appropriate contributing technologies (and demo them where appropriate), and produce a detailed report clearly identifying the scope and general approach for a Phase II system.

PHASE II: Develop and demonstrate a prototype system for use in a military command post executing a SASO mission. It will not be acceptable to have as a result of the Phase II effort, just another report. The resulting prototype must be scalable to a large variety of SASO environments, and must be demonstrable in detail for one or two particular missions such as counter-terrorism or peace-enforcement.

PHASE III: Decision support of management and allocation of scarce resources for biological ecosystems, inter-business competition, market economies, political contests, sports leagues, social ills such as the allocation of famine relief in politically constrained environments, and any other complex adaptive system.

REFERENCES:

1) An excellent "Game Theory" reference is: "Game Theory Evolving", Herbert Gintis, Princeton University Press, 2000. It was written to be an advanced undergraduate/graduate, text. This book is not just another textbook on game theory. Gintis' book vividly demonstrates that game theory, classical and evolutionary, is a powerful tool for understanding the world. There is a wealth of important examples from different disciplines. It is mathematically rigorous.

2) Game Theory-Other books. For texts, listed in decreasing order of difficulty, see: http://www.econ.canterbury.ac.nz/mike2.htm. The list was compiled by Michael Carter, Senior Lecturer in Economics, University of Canterbury.

3) Game Theory Applications - Military. Available via MIT Press Journals, Cambridge, MA. Article "FOX-GA: A Genetic Algorithm for Generating and Analyzing Battlefield Courses of Action", in the journal "Evolutionary Computation", Spring 1999, Volume 7, Number 1.

4) Game Theory Applications - Various. See: "The Evolution Of Intelligent Agent And Game Theory : Towards The Future Of Intelligent Automation", by NK KHOO and Denise JJ CHEN, at http://www-dse.doc.ic.ac.uk/~nd/surprise_95/journal/vol4/jjc1/report.html. Good overview descriptions of game theory and relationships and correlation to artificial intelligence and intelligent agents. A note of interest in Appendix 6 is that the references are given numerical ratings in terms of "Usefulness" and "Readability."

[Important Note. The Army is currently undergoing a major transformation. Therefore, any guiding doctrine is in a dynamic state of flux. Having stated that, the following military references will provide a "sense" of various operations which should assist in a better proposal preparation against this SBIR topic.]

5) Military Reference-SASO. See FM 17-95, "Calvary Operations", Chapter 7, Dec 96, at: http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/17-95/cont.htm (via Adobe viewing) and download capability at: http://www.adtdl.army.mil/cgi-bin/atdl.dll/query/download/FM+17-95.

6) Military Reference-Terrorism, Counter-Terrorism, Peacekeeping, and related. (a) See FM 7-98 (Army), "Operations In A Low-Intensity Conflict", Oct 92, at: http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/7-98/f798.htm. (b) See FM 100-20 / AFP 3-20 (Army & Air Force), "Military Operations In Low-Intensity Conflict", Dec 90, at: http://155.217.58.58/cgi-bin/atdl.dll/fm/100-20/toc.htm.

KEY WORDS: Stability and Support Operations (SASO), Game Theory, Decision Support Tools, Knowledge Acquisition

A01-134 TITLE: Spectrally Efficient High Data Rate Robust Network Waveforms

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM TACTICAL RADIO COMMUNICATIONS SYSTEMS (TRCS)

OBJECTIVE: To develop and demonstrate new and innovative spectrally efficient waveform and modulation technology for hosting on the future JTRS family of software defined radios.

DESCRIPTION: In order to support the transmission of multimedia (voice, video & data) user traffic on the future digitized battlefield, new high data rate efficient network waveforms are required. This technology will allow for more efficient Radio Frequency (RF) spectrum use and increased data throughput, without requiring additional spectral bandwidth (i.e., by achieving more bits per Hertz). Multiple innovative communications techniques (i.e., adaptive link quality & spectrum usage monitoring, adaptive waveform and modulation control schemes, Front End Processor (FEC) Turbo-coding schemes, channel equalization, etc.) should be combined to produce an enhanced overall performance not otherwise achievable. It is envisioned that this technology will be exploited using a Joint Tactical Radio System (JTRS) like software programmable radio platform. This will provide for improved information dominance on the Army digitized battlefield of the 21st century.

PHASE I: A study to evaluate new and innovative waveform and modulation schemes. The study will detail the associated risks, feasibility, and design tradeoffs of each scheme. The study will detail the performance of the waveform, modulation, and recommend suitable control schemes, for a rapidly changing RF communications channel for areas including: spectral bandwidth and data rates, range performance and terrain effects such as fading and multipath, and the resistance to intentional hostile jamming and unintentional interference from Electromagnetic Interference (EMI) environments and cosited friendly radio transmitters.

PHASE II: Complete development and port the resultant waveform software to a JTRS like radio platform, for full performance & characterization testing and evaluation as a possible future Army or Joint tactical network waveform.

PHASE III: There are significant dual use applications in the commercial wireless communications marketplace. Waveform(s) developed under this SBIR could also be implemented within the company's commercial wireless products for use by the general public.

REFERENCES:
JTRS Operational Requirements Document(ORD)

KEYWORDS: Waveform, modulation, JTRS, radio, turbo-codes, digitized

A01-135 TITLE: Innovative Eye Tracking Technologies (for Head Mounted Display (HMD) applications)

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision Close Combat Systems

OBJECTIVE: Incorporate a head/helmet mounted virtual display with minimally intrusive eye gaze monitoring by application of innovative design approaches to achieve: 1) "hands-free" display interface for an improved man-machine interface, 2) localized display optimization for improved display data throughput and 3) display image stabilization under high vibration environments.

DESCRIPTION: The integration of eye gaze monitoring with a head/helmet mounted display would significantly improve the display quality and usefulness in four main areas: 1) hands-free operation of the display interface improves operator efficiency for virtual displays used in system monitoring and control*; 2) the display settings are optimized based on a display region of interest enhancing the lethality of the weapon system for displays used in targeting; 3) stabilization of the display with respect to the operator's gaze improves the mounted and dismounted mobility of a system employing a virtual display for mobility applications; 4) Detail suppression of the display outside the region of interest (defined by eye-gaze position) permits lower bandwidth display drive electronics for lower power consumption, size and complexity thus reducing the man-load for dismounted display applications.

PHASE I: Perform quantitative study of innovative approaches to head/helmet mounted display eye tracking integration. This study should examine several candidate approaches and at a minimum address the following eyetracker/Helmet Mounted Display (HMD) relationships: 1) Head mounted weight/CG, 2) head mounted power dissipation, 3) physical interference with display, 4) display performance impacts (latency, resolution, brightness, etc.), 5) total field of view obscurations and obstructions, 6) environmental susceptibility, 7) Environmental emissions, 8) complexity of donning/doffing/user calibration, and 9) total power consumption. Submit for Government review physical test data from laboratory measurements on one or more candidates of the eye tracking/HMD integration approaches. Establish preliminary eyetracker/Helmet Mounted Display (HMD) concept design based on the "lessons learned" from the quantitative study.

PHASE II: Develop and deliver a brass board system to the Government of a functional eye-tracked, head mounted display for evaluation and testing. The phase II brass board shall contain a monocular display with eye gaze monitoring. The system delivered to the government shall include all cables, display drive hardware, eye tracking hardware and software. The phase II brass board shall demonstrate eye gaze interaction with the virtual display in the ability to select, deselect and modify portions of the display area within the virtual display using eye gaze data.

PHASE III: The eye tracked enhanced performance of an HMD is beneficial both in the military and commercial applications that require hands-free operation, display stabilization, adaptive display optimization and lower drive electronics complexity. The military application will include integration of the eye tracked image stabilization into candidate sensor/HMD systems such as Head Tracked Vision System (HTVS), Land Warrior, or Comanche. Commercial demonstration could be performed by utilizing the eye-tracked stabilization into a medical application like endoscopic or microsurgery.

REFERENCES:
L. E. Sibert and R. J. K. Jacob, "Evaluation of Eye Gaze Interaction," Proc. ACM CHI 2000 Human Factors in Computing Systems Conference, pp. 281-288 Addison-Wesley Press, 2000.

KEYWORDS: Display, Virtual Display, Head Mounted Display, Eye Tracking, Eye control, Image Stabilization, Image Processing

A01-136 TITLE: Miniaturized Fused Reflected/Emitted Light Camera

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PM Night Vision

OBJECTIVE: Develop a miniature-fused camera containing a co-located low light level or near infrared (IR) sensor and an 8-12 micron miniature uncooled camera. This sensor should be capable of being mounted on a rifle or on a helmet. Power and weight are very important and the fused camera shall be less than 1.5 pounds and less than 5 watts.

DESCRIPTION: Current man-portable night vision cameras are limited to a single color. The current image intensifiers are unable to see through smoke and fog, susceptible to camouflage, and unable to see in total darkness. The current uncooled cameras have an image resolution about 10X less than existing image intensifiers, can not see ditches and rocks, and cannot see aiming lights. Advances in CMOS low light level sensors, uncooled cameras, and fusion techniques now enable the fabrication and design of a miniature fused two color sensor that can see reflected and emitted light. This combination can reduce the limitations of each sensor and increase the capability of the combined sensor.

PHASE I: Design a miniature fused reflected/emitted light sensor. The design shall include the two fused cameras, collocation, and fusion technique.

PHASE II: Develop a brass board unit to demonstrate the principles. Both cameras shall have state-of the art performance (low light level sensitivity and low NETD for the thermal camera).

PHASE III: The phase three commercialization of this technology includes night vision driving aids, search and rescue, low light level surveillance, firefighter helmets, law enforcement devices, and wireless remote surveillance.

REFERENCES:
1) Howard, P. et al, "Advanced High Performance 320X240 Vox Microbolometer uncooled IR Focal Plane" SPIE 13th Annual International AeroSense Symposium, Session 3698, Paper 3698-19 (April 1999)
2) Radford, W., et al, "Sensitivity Improvements in Uncooled Microbolometer FPAs (U), 1999 Meeting of the IRIS Specialty Group on Passive Sensors, Paper F-1 (February 1999)

KEYWORDS: Uncooled, Image Intensifier, Fused image

A01-137 TITLE: Aerosol Collection Technology

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop new aerosol collector devices, including inlets, to maximize the quantity of aerosol collected on dry and wet substrates in the 1-10 micrometer size range while reducing the portion of the aerosol outside of this range. Optimize collectors to reduce collector size, weight, cost and power requirements.

DESCRIPTION: An aerosol collector system contains up to three components: an Inlet which extracts the particles from the air which may be rushing past the system at high speed (aspiration), a Concentrator to greatly reduce the volume of air in which the aerosol particles are dispersed , and a Collector which extracts the aerosol particles from the air and deposits them in concentrated form on a solid substrate or in a small amount of liquid. There are also associated ducts to convey the sample among the three components. Opportunities to improve collector system characteristics include improved conventional designs and entirely new aerosol collector concepts. Aerosol collectors are required for all point biodetection systems and future chemical point detectors. Current chemical detectors have no aerosol capability, and biological detectors use aerosol collectors that are too big, heavy, and power consuming due to moving large volumes of air against significant pressure drops inherent in their collection techniques. The inlets to the aerosol trigger and aerosol collector in these systems have low efficiency in extracting aerosols from the ambient wind and in transmitting the aerosols through the inlet ducts to the instrument, especially at the higher wind speeds and larger particles sizes of the Joint Service requirements.

PHASE I: The contractor will design aerosol collection systems with target aspirations of 600 l/min and 100 l/min. He will employ computational fluid dynamics, with particle trajectory tracking, software to describe the collector behavior and predict its collection efficiency for a particle size range of 0.5 to 20 micrometers at several wind speeds spanning the range 0 to 40 mph. He will estimate the size, weight, and power requirements of such a collector. At both target aspirations (100 and 600 l/min) the target collection efficiency, e, should be e>=50% over the aerodynamic particle size range 1 to 15 micrometers, and e>=80% over the sub-range from 2 to 10 micrometers, all at wind speeds less than 10 mph. The target efficiencies may be reduced by a factor of 2 for wind speeds above 10 mph up to 40 mph. The target collector volume is less than 1 cubic foot, with a weight less than 15 lbs.

PHASE II: In this phase a successful and promising design from Phase I will be optimized for specific collection characteristics in consultation with the government. The contractor will build a complete functioning prototype of the collector and test its characteristics in aerosol chambers and/or wind tunnels over the size and speed ranges specified in Phase I. The prototype will be delivered to the government for independent testing and verification.

PHASE III DUAL USE APPLICATIONS: It is anticipated that the collector(s) developed in this program will be integrated into CB-detection units fielded for Joint Service use. Applications exist in other government activities such as Treaty Verification, Domestic Preparedness, and Demilitarization. Civilian applications should be discovered in many areas such as medical monitoring and food packaging.

REFERENCES:

1) G.Hongrui, S.Chandra, A.R.McFarland and N.K.Anand; A Predictive Model for Transmission through a Shrouded Probe ; Environ.Sci.Technol. 1996, 30, 3192-3198
2) A.Muyshondt, A.R.McFarland and N.K.Anand ; Deposition of Aerosol Particles in Contraction Fittings ; Aerosol Science and Technology, 1996, 24, 205-216
3) A.R.McFarland and C.A.Ortiz ; A 10 micron Cutpoint Ambient Aerosol Sampling Inlet, Atmos. Environ. 1982, 16, 2959-2965

KEYWORDS: aerosol, aerosol collector, inlet, concentrator, biological collector, chemical and biological detector, aerosol sampling

A01-138 TITLE: Using High Resolution Multispectral and/or Hyperspectral Imagery to Improve Digital Land Cover Classification From Low Resolution Multispectral Imagery Over Large Areas

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop automated or semi-automated techniques that employ samples of high resolution multispectral imagery (HRMSI) and/or high resolution hyperspectral imagery (HRHSI) to improve low resolution multispectral imagery (LRMSI) land cover mapping over large areas.

DESCRIPTION: For many years, extraction of land cover classes from digital data has been performed using low resolution multispectral imagery, such as 30 meter LANDSAT. Due to the relatively large pixel size of this data, it is often difficult to perform more than a crude land cover classification from this data. For instance, it may be possible to describe an area as forested but at times not be able to classify the forest as evergreen or deciduous.

Recently, high resolution multi-spectral imagery at less than 5 meter resolution has become more readily available. Studies have shown that a more precise land cover classification is possible using data at this resolution. However, automated mapping of large areas using HRMSI is not feasible for several reasons. First, commercial HRMSI is currently very expensive. For most users it would be cost prohibitive to purchase commercial HRMSI to cover an entire LANDSAT scene (185 km x 178 km). Second, the high spatial resolution of commercial HRMSI is generally offset by a loss of spectral bands. LANDSAT has seven spectral bands; a current commercial HRMSI sensor has only four. This means that features that may be spectrally differentiable with seven bands may not be spectrally differentiable in the four band imagery. HRHSI would fare better in this regard, but its availability is currently more limited than HRMSI. However, the availability of HRHSI is anticipated to increase in the near future.

It may be possible to use selected samples of HRMSI and/or HRHSI combined with LRMSI to produce better land cover digital classification results. It is anticipated that the land cover map will be more accurate and detailed using the HRMSI and/or HRHSI samples than using the LRMSI alone. If it is determined that the HRMSI and/or HRHSI samples enhance the LRMSI classification over large areas, determining an automated or semi-automated approach to selecting the samples is a core research issue.

PHASE I: The contractor needs to accomplish three research goals. First, develop an automated/semi-automated methodology using HRMSI and/or HRHSI samples to improve the land cover classification from LRMSI over large areas. Second, develop an automated or semi-automated approach to selecting sample tiles of HRMSI and/or HRHSI over a large area - specifically a LANDSAT scene. The approach must allow for flexibility in terms of the number of samples and the size of the tiles; i.e., the number of samples and the size of the tiles are not static. The sampling approach must be more rigorous than a mere random sample. Characteristics of the LANDSAT scene can be used as a basis for the HRMSI/HRHSI sample(s). Third, develop an automated or semi-automated approach(s) for using these samples in conjunction with the LRMSI to improve digital land cover classification. The Government will coordinate with the contractor to define the feature classification scheme after contract award. However, the minimal goal is to accurately extract the broad features described in the National Imagery & Mapping Agency (NIMA) Foundation Feature Data (FFD) specification. A secondary goal will be to extract a subset of the more detailed features and attributes from the NIMA Digital Topographic Data, Level 3 (DTOP3) specification.

PHASE II: The contractor will develop the processing capabilities that are defined in Phase I into a prototype system. The prototype system will further develop and enhance the capabilities developed in Phase I. Testing will occur with as much data as time and budgetary constraints allow. Ideally, a test case will be developed over an Army-determined area of interest and the contractor will perform an accuracy assessment to determine if the incorporation of HRMSI and/or HRHSI actually improves the land cover classification beyond that of using LRMSI alone.

PHASE III: This SBIR would result in a technology with broad applications in the civil and military communities. With strapped resources, many in the civil and military communities are trying to determine how to make best use of expensive HRMSI/HRHSI for their mapping applications. The automated sampling and integration of HRMSI/HRHSI tiles to support and improve large area mapping from LRMSI will benefit a wide variety of users.

REFERENCES:
1) Chilar, J., Latifovic, R., Chen, J., Beaubien, J., and Li, Z. "Selecting Representative High Resolution Sample Images for Land Cover Studies. Part 1: Methodology." Remote Sensing of the Environment 71 (January 2000), pgs. 26-42.
2)Chilar, J., Latifovic, R., Chen, J., Beaubien, J., and Li, Z. "Selecting Representative High Resolution Sample Images for Land Cover Studies. Part 2: Application to Estimating Land Cover Composition." Remote Sensing of the Environment 72 (February 2000), pgs. 127-138.
3) Moody, A. "Using Landscape Spatial Relationships To Improve Estimates of Land-Cover Area From Coarse Resolution Remote Sensing." Remote Sensing of the Environment 64 (1998), pgs. 202-220.
4) Walsh T.A., and Burk, T.E. "Calibration of Satellite Classifications of Land Area." Remote Sensing of the Environment 46 (1993), pgs. 281-290.

KEYWORDS: Hyperspectral Imagery, Multispectral Imagery, Large Area Mapping, Image Sampling, Digital Land Cover Classification

A01-139 TITLE: Army Communications Through an Exclusive Transmission and Multiple Receiver Intelligent Organizer System (IOS) Network

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research & development of an integrated hand held, pocket PC personal digital assistant (PDA) and cellular phone system that is a part of a wireless networked, Global Positioning System (GPS)-enabled communication system. This system is standby for warfighter, emergency troop movement commands any terrorist security responses, and natural disaster emergencies. It will be maintained in a routine business process context to support map-based geospatial information and DPW maintenance operations. Both operational and emergency applications will use reporting-form screens, geospatial and information display, and cellular voice.

DESCRIPTION: The PDA type organizers are now being linked to internet transactions commercially; it has also been usefully applied at Fort Wainwright AK; and a cellular phone and voice recognition system is on-line at Fort Polk LA. The potential integration and Army-wide availability of these capabilities is original to this proposal and holds the promise of a significant improvement in ALL TYPES OF MILITARY AND CIVIL FIELD COMMUNICATIONS. The emerging PDA units can be programmed to special needs in combination with a cellular phone for real-time data transmission to single or multiple hand-held PDA units. These units can be strapped to the user's belt and carried like a cellular phone.

Although the cell phone and PDA are well developed, several critical technology areas need to be addressed in creating a useable, secure, reliable, untraceable, tactical, wireless networked communication system for the Army. And these issues need to be addressed within the current framework of standards and protocols.

- Security issues on wireless systems
1. Efficient/timely encryption and decoding of complex geospatial information designed for small screen display
2. Stealth communication so that the soldier, engineer, or emergency operations worker requesting or sending information cannot be located by hostile forces when using the system

- Compression and prioritization techniques
1. Making large data packs receivable and useable with limited memory
2. Making access to large compressed data bases selective as to what information gets displayed on small screens on small systems with limited memory
3. Making rapid transmission of data possible to reduce air time needed
4. Development of advanced selection/prioritization schemes
5. Development of good compression techniques to work with Condor encryption

- Addressing limited bandwidth issues and designing the architecture accordingly; e.g., what geospatial information is static and can be retained locally on PDAs, and what geospatially referenced information is dynamic and must be updated over the wireless network.

- Establishing, at an acceptable cost, the needed quantity of mobile ground, air, or space-based cell stations for use on the battlefield, and for worldwide humanitarian relief and emergency response efforts.

PHASE I: An overall development plan in which wireless applications and secure operations configuration(s) and performance practices are defined. An on-site visit and verification evaluation of the developed concepts. A coordinated Overall Development Plan. A Concept Design (CD) of the interface module to be inserted into the PDA interface slot and of the security, bandwidth, compression, selection, prioritization, and cell station components required for the functional software applications.

PHASE II: On-site demonstration(s) and evaluation of the total Intelligent Organizer System (IOS) concept. Demonstrate prototype module for insertion into PDA and module integration to software applications. Finalized design of a Prototype IOS for on-line field developmental testing. An on-site field and validation test of the Prototype IOS; the accepted system and associated intellectual property to remain at this and future sites as Government property.

PHASE III: Development of commercialized IOS capabilities.

REFERENCES:
1) FY2000 SBIR Program, DOD Publication: Palm Co. literature.
2) Institute of Electrical and Electronics Engineers, Proceedings of the Custom Integrated CIrcuits Conference, 2000, 1998, 1996, IEEE, Piscataway, NJ.
3) Institute of Electrical and Electronics Engineers, International Electron Devices Meeting, M. Hargreve et al., 1998, IEEE, Piscataway, NJ.

4) Yosef G. Tirat-Gefen et al. "Incorporating Imprecise Computation Into System-level Design of Application-specific Heterogeneous Multiprocessors," Proceedings of the 34th Annual Conference on Design Automation, June 9-13, 1997, Anaheim, CA, Association for Computing Machinery, New York, NY, pp 58-63.
5) J.J. Engel et al., "Design Methodology for IBM ASIC (Application Specific Integrated CIrcuit) Products," IBM Journal of Research & Development, v40:4, July 1996, IBM, Yorktown Heights, NY.

KEYWORDS: Handheld electronic organizers; Pocket PC; Microsoft/Palm OS software; PDA; GIS; Wireless internet.

A01-140 TITLE: Rapid Detection and Mapping of UXOs and Munitions Contaminants

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

OBJECTIVE: To develop a suite of airborne-dispersed fluorescent tags or substrates to be broadcast over suspected areas containing unexploded ordinance (UXO) that will fluoresce in the presence of common munitions fillers TNT, RDX, HMX, as well as primary explosives. The fluorescent tags will be used in conjunction with a laser-induced fluorescence imager to synoptically characterize areas of contamination based upon imagery signatures.

DESCRIPTION: Buried landmines and waste munitions continue to be a threat to both the warfighter and indigenous civilian populations. Buried landmines and UXO material are leaky, volatile and are typically distributed heterogeneously in soil, with their residues offering a greater (vertical and horizontal) spatial distribution than for many organic wastes (i.e., PCBs and organophosphates and organochlorides). Experimental data from 11 munitions sites reported by US EPA in 1992 for the distribution of TNT and RDX compounds showed that the mean coefficient of variation (standard deviation divided by the mean) for these materials in soils was 284% for TNT and 127% to 203% for RDX. These values can be compared to other volatile compounds such as PCBs that are rated at up to 54%. The recommendation by EPA for the detection and characterization of these materials was to collect more samples for greater spatial representation.

The heterogeneous nature of these volatile materials lends itself to a detection method that can confidently characterize large spatial areas using airborne remote sensing techniques. This is rule rather than the exception in the theater of war, where it would be a luxury to sample areas and run standard methods assays to indicate the presence of UXOs and their associated volatiles. Current advances in laser-induced fluorescence imaging (LIFI) coupled with programmable fluorescent tags can serve to rapidly detect and map contaminated areas. The development of fluorescent tags and the appropriate airborne delivery system (fixed versus rotary wing) should permit the characterization of UXOs in denied areas and represent a novel way to remotely sense non-metalic mines and characterize their spatial distribution using fluorescence. Also, airborne detection of the UXO areas could be fairly clandestine since fluorescence is an electro-optical phenomenon best observed in darkness (dark-field).

Significant research will be required to identify and isolate substrate compound(s) that posses the ability to bind with explosives and their volatile constituents in soil-vegetation matrices. These substrates will need to express detectable levels of fluorescence once in contact with explosive material. Furthermore, the substrates will be required to be broadcast over large spatial areas and must have stability under a variety of weather conditions to maintain efficacy. Risks associated with this research involve defining a substrate compound with the proper binding mechanism, stability of fluorescence expression (i.e., amount of explosive in contact with the substrate to elucidate fluorescence and decay rates), distribution within a vehicle, quantification of explosive based on fluorescence expression, and assurance of environmental compatibility.

PHASE I: Laboratory proof of concept of specific specific ultraviolet-stimulated fluorescent tags or substrate compounds that can be used together or separately to combine with the chemical constituents of TNT, RDX and HDX as well as metal-based primary explosives. Tagging agents or defined substrates will need to be contained within a non-UV fluorescent vehicle for distribution over a suspected area.

PHASE II: The contractor will be required to conduct rigorous laboratory and field tests using photoluminescence spectrometry to independently validate the signatures produced from the substrate(s) when combined with munitions. Statistical validation of the signatures will be required to place confidence limits on the detection technology. Environmental considerations of any tagging agent or substrate developed will also need to be addressed by the contractor including toxicity, fate, transport, and persistence in the environment. A delivery system will be designed, and will be demonstrated on a very small scale.

PHASE III: The contractor will demonstrate the aerial distribution and broadcast of the fluorescent tag(s) at several CONUS military bases with known and unknown areas of UXO and munitions contamination. One possible scenario could involve broadcast of a tagging agent by fixed-wing aircraft similar to the distribution of fire retardant chemicals. This may require that the tag(s) and their constituents to be mixed on the aircraft platform en-route to a target and then dispersed. Both field and

laboratory signatures analysis from the test sites using total luminescence spectroscopy and LIFI will be required to validate the success and potential fate of tag agent(s) such as fluorescence decay. The contractor will be required to report statistically valid confidence limits of detection, residence time of the tagent, operational limitations with different soil types, and overall efficacy.

The contractor will develop the tag(s) generated in Phase I and the delivery capability (designed in Phase II) into a prototype system. A final testing phase will certify and validate the results achieved in the first two phases of the SBIR.

PHASE III: This SBIR will result in a technology with broad applications in the military and civilian sectors. The danger from UXOs and munitions contaminants is sustained within both the United States and her allies. In the U.S., base re-alignment and closure (BRAC) will require the reclamation of abandoned military bases. Additionally, countless rogue mine fields and munitions contaminated sites are widely distributed throughout the third world. The technology described will offer a way to spatially characterize affected areas as well as provide the necessary information for mitigation and reclamation.

REFERENCES:
1) USEPA. 1992. Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3, Reference Based Standards for Soils and Solid Media. EPA 230-R-94-004, US EPA, Washington, DC.
2) Haas, R.A., and B.P. Simmons. 1995. Measurement of TNT, HDX, and RDX in Soil by Enzyme Immunoassay and High Performance Liquid Chromatography. California EPA, Department of Toxic Substances Control, Hazardous Materials Lab Report.

KEYWORDS: Fluorescence, Munitions, Detection, Unexploded ordinance, TNT, RDX, HDX

A01-141 TITLE: Methods of Displaying Digital Graphic Data on Small Display Screens

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To determine if digital map, digital terrain and digital symbols can be usefully displayed on small screen displays in a manner that will allow the user to easily employ the same terrain interpretation skills that are currently used with paper maps to get a "feel" for the terain. If a method/technique is determined, to develop a software package that implements it on computer platforms normally used to drive the small screen displays.

DECSRIPTION: The soldier's ability to get a "feel " for the terrain from maps before he walks or even while he walks the terrain is key to the success of a mission. Contour lines, symbols on the map and training allow the soldier to "feel" the terrain. If a view of a larger area of operation is needed, the paper map is just moved a little farther from the eyes. The contour lines and other map information are still clear and support the soldier's interpretation of the terrain.

The dismounted and mounted soldier of the future will have text and graphic information displayed on small screen displays. In the commercial world, cars, handheld GPS receivers, cell phones and other items will also present digital information (text and graphic) to the user. Some of the digital graphic information will be digital maps, digital terrain data and digital map symbols. For a view of a larger terrain area, the soldier must zoom out. On large screen displays, the user can often use the same skills for interpreting the terrain and symbol information that were use with paper map products because the contour lines and other map symbols are still clear. On the small screens planned for use in the future, the contour lines blend together and the map symbols tend to become too small. Thus digital map display cannot support the soldier's terrain interpretation skills.

Large, powerful systems use techniques like perspective views, sun-angle shading of digital elevation data, binocular and monocular 3-D effects, colored digital slope maps and other methods to give the user a "feel" for or to visualize the terrain. This effort will investigate these current display methods, display methods under development, and any other method for use on small, less powerful systems with small screen displays. These will be assessed for their potential to be transitioned to systems with small displays and for allowing the user to use these same skills when presented on a small screen display. If a method or methods are identified, the best candidate for use on many computer platforms will be implemented.

PHASE I: Identify current and developing digital information display methods and techniques for large screen display that have the potential to aid the user's ability to get a "feel" for the terrain. Assess the potential for transitioning these methods/techniques for use in displaying the digital data on small screen. The Contractor should consider the current and developing binocular and monocular methods for presenting digital terrain information with 3-D effect and assess the potential for transitioning to small display screens some of which are viewed with one eye. The contractor will take into consideration that the computing power, RAM and storage are normally limited. If the contractor determines that a method or technique can be use for small screen display, the contractor will develop an approach/design for implementing his findings.

PHASE II: The contractor will take the approach/design determined in Phase I and implement it. The contractor will demonstrate his implementation.

PHASE III: The product developed would have utility by the civil side of government and the commercial community. The capability will enhance products such as handheld GPS receivers, automobile navigation/information systems, and personal navigation system for recreational and emergency use.

REFERENCES:

1) "Determining the Best Content of Digital Terrain Data (DTD) for Small Screen Display and Assessing the Ability of NIMA to Support this Display Final Report", August 1998, SAIC

2) Commercial Terrain Visualization Software Products Information, http://www.tec.army.mil/TD/tvd/survey/survey.wpd

3) PC - Digital Terrain Elevation Data DTED Display Software, http://www.tec.army.mil/spftware/dted.html

KEYWORDS: small screen display, terrain data, digital graphic information, heads-up display, terrain interpretation

A01-142 TITLE: Soil Prediction Modeling

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Knowledge of soil moisture conditions is critical to both military and civil operations. The objective of this topic is to develop a method for accurately predicting soil moisture conditions without the advantage of field or remotely collected soil moisture data.

DESCRIPTION: A four-step experimental design approach is proposed that exploits conventional data source and GIS technology advances. In sequence, the proposed steps are (1) drainage pattern contribution, (2) landform, (3) vegetation community expectation of soil conditions, and (4) stream classic stereographic photo interpretation. Soil condition assumptions are made and modified as decisions are rendered regarding drainage pattern, vegetation community, and streambed shape. Predicted soil conditions are to be generated through this model and, ultimately, measures of uncertainty related to the predictive power of each model response.

Multi-disciplined interpretive terrain analysis is suggested to a) examine the relationships between major terrain themes (drainage, landform, vegetation types, cultural (transportation, housing), and unusual features and b) analyze within-theme defining characteristics. Today, geographic information systems supplemented with knowledge based rules are available for use in examining and predicting terrain inter-relationships. Research may wish to consider the use of the following technologies: ArcView GIS, Erdas Imagine image processing, and high resolution Digital Elevation Models and algorithms to process them.

Previously undefined relationships must be established between terrain and soil conditions, and new technologies applied to develop an integration strategy for modeling soil characteristics and predicting soil moisture conditions. The system must be designed to accept locally entered watershed precipitation history and conditions, known or estimated, for the area of concern, so that current and predicted soil moisture conditions can be estimated.

A proposed model is outlined below, as well as the rationale for its inclusion in predicting soil conditions.

(1) Drainage Pattern Contribution
Identification of the drainage pattern is important because it provides direct and predictive information about the terrain within the area of interest. Physical, cultural, and biotic characteristics of an environment can be better understood through careful drainage pattern analysis.

(2) Landform Contribution to Soil Prediction
Landform can assist in soil prediction. "A hilltop (summit) lies above the convex segment or shoulder. Below the shoulder is the backslope that contains the point of inflection. The lower slopes include the concave segment or footslope and the bottom segment or toeslope" (Ruhe, 1965). Colluvium deposits (coarse, poorly bedded and sorted, and moved primarily be gravity) will form in the backslope and upper footslope while alluvium deposits (better bedded and sorted) in the footslope and toeslope. Knowledge of location along a hill slope, based on DEM analysis, should provide another clue as to soil condition.

(3) Vegetation community expectation of soil conditions
Vegetation and soil relationships are established in the literature. Certain plant species prefer soils of particular texture and moisture. Comparison of plant species and their associated preferred soil conditions can assist in filtering out predicted soils and can contribute to the certainty of soil characteristic prediction. Several methods of vegetation data generation can be considered separately or in combination, with each vegetation product useful as an indicator of soil conditions.

(4) Stream gully shape stereographic photo interpretation (waterfalls, stream shape, sedimentation, inside/outside river bends as surrogates to steepness of surrounding terrain).

PHASE I: Select a project location and develop an architecture for a rule based soil moisture prediction system. Show proof of concept incorporating local rainfall patterns over an appropriate time span.

PHASE II: Demonstrate soil moisture prediction system at two diverse sites. Moisture prediction system will incorporate watershed precipitation and snowpack conditions, as applicable for demonstration locations. Test results against ground truth and make modifications as necessary.

PHASE III: Expand development for application at other geographic environments. Transition to Army fielded system and commercial markets. Commercial interest should materialize from the engineering, mapping, flood management, and natural resource management communities.

REFERENCES:
1) Ruhe, R. 1965. Geomorphology, geomorphic processes, and surficial geology. Boston, Houghton, and Mifflin Co., 246 p.)
2) Gessler, P.E., Moore, I.D., McKenzie, N.J., and Ryan, P.J., (1995).
Soil-landscape modeling and spatial prediction of soil attributes. International Journal of Geographic Information Systems, 9 (4): 421-432.
3) Gessler, P., McKenzie, N., and Hutchinson, M. (undated, follow-on to work in 1995). Progress in Soil-landscape modeling and spatial prediction of soil attributes for environmental models.
Found at site http://ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/gessler_paul/my_paper.html
4) Moore, I.D., Gessler, P.E., Nielsen, G.A., and Petersen, G.A. (1993). Soil attribute prediction using terrain analysis. Journal of Soil Science America, 57:443-452.
5) Franklin, J. (1995). Predictive vegetation mapping: geographic modeling of biospatial patterns in relation to environmental gradients. Progress in Physical Geography, 19 (4): 474-499.

KEYWORDS: soil prediction, modeling, expert system, Digital elevation model, terrain analysis

A01-143 TITLE: Dynamic Sand Table

TECHNOLOGY AREAS: Information Systems

BACKGROUND: Sand tables, or physical terrain models, are a key element in planning, rehearsing, and reviewing military operations. They are preferred for terrain visualization, because soldiers easily recognize their scaled representation of the earth. Despite their advantages, sand tables have two distinct disadvantages, 1) they are time-consuming to construct and manufacture, and 2) they become a storage problem when multiple tables are acquired.

OBJECTIVE: The objective of the Command Post Dynamic Sand Table SBIR is to research and develop the technology to create a physical terrain model with a surface that can be reconfigured based on digital terrain data. The height of the locations on the table surface will be proportional to the elevation of the terrain, with an exaggeration specified by the user.

DESCRIPTION: The Dynamic Sand Table will be able to depict any area as long as the underlying terrain information is available. In addition to displaying the elevations of the terrain, the surface of the table should also support the display of image, map, live and dynamic intelligence data, and thematic information, such as topography or land cover. The dynamic intelligence data and thematic information shall also come from existing databases.

The Dynamic Sand Table will offer the advantages of the physical terrain models, without the disadvantages of manufacturing delays and storage problems.

PHASE I: In Phase 1, the Contractor will demonstrate the technology by creating a 2'x2' Dynamic Sand Table. The table surface will be defined by the elevation data, map and image data, live-dynamic intelligence data, and thematic map information will be displayed on the surface. The Contractor will demonstrate the technology by displaying National Imagery and Mapping Agency (NIMA) data over two different geographic areas. The table should reconfigure itself in less than three minutes.

PHASE II: In Phase 2, the Contractor will build a 4'x8' prototype Dynamic Sand Table with the same elevation and display capabilities as Phase 1. In addition, the table should reconfigure itself in less than one minute. The Contractor will demonstrate the technology by displaying NIMA data over ten different geographic areas.

PHASE III: The Dynamic Sand Table will be suitable for non-military planning applications, such as emergency management, disaster relief, natural resource planning, and as local and state government planning.

REFERENCES

1) Kai, Chua Chee and Leong Kah Fai. (1998) Rapid Prototyping: Principles and Applications in Manufacturing. John Wiley & Sons, Incorporated.
2) Beaman, Joseph J. et. al. (1996) Solid Freeform Fabrication: A New Direction in Manufacturing. Kluwer Academic Publishers.
3) Kochan, Detlef. (1993) Solid Freeform Manufacturing: Advanced Rapid Prototyping. Elsevier Science.

KEYWORDS: Terrain model, sand table, spatial data

A01-144 TITLE: Miniaturized, Synchronized, Data Acquisition System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To design, develop and fabricate a miniaturized, digital, synchronized combination signal conditioning and data acquisition system for airblast, acceleration, temperature (using laser/infrared gage), strain, velocity and other transient dynamic measurements. For the system to be successful in recording relevant data for the Survivability and Protective Structures community, a synchronized clock system controlling all of the remote data acquisition recorders must be designed, developed and fabricated. A system without the synchronized timing capabilities would be of limited use and is probably currently available from off the shelf technology. Current technologies do not support miniature synchronized timing systems accurate enough for use in remote data acquisition systems with a frequency response of 1 MHz.

DESCRIPTION: Survivability and Protective Structures research as well as research in many other technical areas involves experimental analysis and the electronic measurement of complicated dynamic loads and resulting responses. Many of these experiments are at very remote locations. There is a great need for a system to provide signal conditioning and data acquisition capability in close proximity to the transducers. Such a system should have small, stand-alone units that could be placed next to individual transducers to record the data from the transducers. The units should be able to down load the data to a portable computer after the experiment.

The system should have approximately 30 stand-alone channels with a minimum sampling rate of 1 microsecond per point and a minimum memory of 1 megabyte per channel. Further, the system should have an easy-to-use, PC-compatible interface and software for setup and download. Each channel unit should contain an accurate clock that can be synchronized with all other channels, so that, one unit could be used for zero-time while the other channels could be discriminator tripped. The total system should be of a size and weight to be easily carried by a single person.

PHASE I: Conduct a feasibility investigation, select most appropriate concepts, and prepare a preliminary design. The feasibility investigation must include at least two alternatives that address the criteria described above. The investigation must include a comparison analysis of alternatives considered. A preliminary design should be prepared. This initial design should include as a minimum: specifications on components (composition and properties) and assembly (operational capabilities), interface and control software, estimated cost, packaging/ transportability, and estimated component size and weight(s).

PHASE II: Prepare final design and construct full-scale prototype(s). Samples must be prepared to evaluate performance in weapons effects experiments. Full-scale system prototype must be constructed to evaluate construction requirements, efficiency, packaging, and overall system performance. Refine the prototype system as deemed necessary from the results of laboratory and field trials. Documentation should be prepared to define construction tactics, techniques, and procedures (TTPs), and fully describe applications and limitations of the developed system(s).

PHASE III: Results of this effort would likely be applicable to all levels of the research community.

REFERENCES:

1) Franco, Raphael A. Jr., A Self-Contained Shock Hardened (100KG) Data Acquisition System, Report 1, Design and development, U.S. Army Engineers Waterways Experiment Station prepared for Defense Nuclear Agency, June 1988.
2) Franco, Raphael A. Jr., and Owens, John K., A Miniature, Shock Hardened, Transient Data Recorder, U.S. Army Engineers Waterways Experiment Station, prepared for 66th Shock and Vibration Symposium, Nov 1995.

KEYWORDS: Survivability, signal conditioning, synchronized, and data acquisition

A01-145 TITLE: Rapid Determination of Field Density and Moisture Content

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and build both the hardware and software components of a system for measuring in situ moisture content and density of pavement materials. These measurements would then be used for either: (1) predicting pavement performance under known sustained traffic, (2) classifying the pavement's structural capacity in terms of a numeric parameter, such as a military load classification (MLC) number, and (3) performing quality assurance/quality control during construction of military pavements.

DESCRIPTION: The traditional methods of measuring density and moisture content under field conditions are limited in terms of either their applicability to different materials or their ease of use. The traditional methods of determining in situ density by either the sand-cone or drive-cylinder methods are obsolete. The sand-cone method is very time consuming and extremely dependent upon the operator's experience. The drive-cylinder method is simpler, but it is only appropriate for cohesive soils. Moisture contents have traditionally been measured using the oven-dried procedure, which is extremely time consuming and often results in needless construction delays. The nuclear method of determining density and moisture content has demonstrated the capability of accurately measuring wet density using radioactive isotopes, but has produced inaccurate moisture content measurements in certain soil types. The major obstacle to using the nuclear moisture/density gage is that the radioactive sources are heavily monitored. This fact makes transportation and use of the gage very difficult, especially for military applications in which the device must be shipped across state or national borders. Personnel are also required to attend a special workshop on safe handling of the nuclear gage in order to become certified to use the device. In addition to these application-oriented obstacles, the nuclear gages require frequent monitoring for leaks and a stringent exposure-monitoring program for the operating personnel (1-3). In the recent past, many devices have been marketed as tools for expedient measurement of moisture content and/or density. Unfortunately, most of the devices have displayed poor accuracy and repeatability characteristics.

Our military engineers are required to make rapid determinations of the strength characteristics of its domestic infrastructure and theater of operations materials. Troops are often required to perform measurements under duress and time is a critical factor in almost every military operation. The tools currently used by military engineers are inadequate for completing their mission requirements in a timely and accurate manner. Often, they are forced to perform a low number of tests or make qualitative assessments without proper numerical justification. These situations result in a reduced reliability in the overall design or engineering assessment of the material. The development of an improved method for rapidly measuring moisture content and/or density will greatly enhance the capabilities of the Army's objective force by significantly reducing logistics requirements.

To ensure that the moisture content/density measurements provide rapid and accurate information, the following requirements must be met. The equipment must enable the user to measure moisture content and/or density at selected locations along the length of a roadway. The device may perform measurements on the surface of the pavement or using small (< 1.5 in.) apertures bored through the pavement layer. The device must be capable of measuring density/ moisture content for a minimum depth of 6 inches. Measured density measurements must be accurate to within + 1 pcf of the density measured by either the sand-cone device or a nuclear device augmented with oven-dried moisture contents. The moisture content measurements must be accurate to within + 0.2 percent of oven-dried measurements. The equipment must be repeatable and demonstrate a coefficient of variation of less than 10 percent for each type of test, wet density and moisture content. The equipment must be able to complete measurements within 5 minutes. If software must be developed, it must provide the ability for the user to calibrate the device. Internal storage of gage measurements is desirable but not essential. If the test data is stored internally, it should be easily accessible for importing into standard spreadsheets for analysis. The device must be lightweight to accommodate mission objectives. The maximum weight of the system should not exceed 40 lb. The device should not require any special monitoring by regulatory agencies.

The developer of the system is free to use any available technology to accomplish the specifications indicated. However, the use of restricted or heavily monitored technologies, such as radioactive isotopes, will not be permitted. The use of the following technologies may provide a starting point for development: seismic wave analysis, ground penetrating radar (GPR), thermal imaging, sonar technology, chemical analysis of physical samples, accelerometers, cone penetrometers, microwave technology, and/or unmonitored energy sources. The proposals should not contain technology that are potentially hazardous for environmental or health reasons.

PHASE I: Conduct feasibility investigation, select the most appropriate technology, and prepare a preliminary hardware design. The feasibility investigation must describe at least three alternative technologies and it must explain the advantages of the selected technology, relative to those that were considered and were then dismissed. Preliminary hardware design must include an approximate cost of production, a description of any safety hazards, and an explanation of any availability issues related to equipment components.

PHASE II: Prepare final design and construct working model. Demonstrate the model system and compare selected density/moisture content measurements to measurements made using the traditional methods identified above. Refine the hardware and software components as deemed necessary from the demonstration.

PHASE III: This system would be useful for pavement evaluation, construction, and management applications by both military installation personnel and civilian agencies such as state departments of transportation.

REFERENCES:

1) Rollings, M.P. and Rollings, R.S., "Geotechnical Materials in Construction," McGraw-Hill, New York, NY, 1996.
2) U.S. Army, "Materials Testing," Field Manual FM 5-472, U.S. Army Engineer School, Fort Leonard Wood, MO, 1997.
3) Waterways Experiment Station, "Field Density Determinations by Sand Volume and Drive Cylinder Methods," Instruction Report No. 2, U.S. Army Waterways Experiment Station, Vicksburg, MS, 1957.

KEYWORDS: pavements, density, moisture content, quality control, material characterization

A01-146 TITLE: Nondestructive Life Prediction for Reinforced Concrete Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a nondestructive testing (NDT) instrument that can determine the condition of reinforcing steel elements embedded in concrete structures such as bridges and dams. A theoretical basis for predicting strength and remaining life of buried elements, hardware to generate and detect the necessary signals, and software for processing the received signals to yield quantitative measurements of remaining life and/or the degree of corrosion present will be developed. Key considerations are that the developed instrument (1) must be usable in situ with single sided access on civil structures, (2) must not require any regulatory oversight or create any environmental problems, and (3) must produce quantitative results related to material properties and/or geometry.

DESCRIPTION: Concrete structures contain various buried pre-stressed or post-tensioned metal elements which are subject to corrosion due to the presence of chlorides. Currently such reinforcing elements are maintained using visual inspection or isotope radiography, and corrosion quantification has been attempted via tap testing with hammers. These techniques do not yield good data on the condition, integrity and functioning of these reinforcing elements. What is needed is a NDT instrument that could determine the remaining life of these strengthening elements and/or the degree of corrosion present. Various NDT technologies, such as acoustics and electromagnetics, offer a good basis for a solution, because their signals are affected directly by the material properties or the geometry of the material in which they are traveling, leading to quantitative measurements. Further, these techniques are environmentally friendly, are theoretically capable of traveling long distances in engineered structures, and can thoroughly interrogate a structure's integrity. Metal rods and cables surrounded by concrete require that very low frequencies be used, as high frequencies have larger attenuation coefficients and hence a shorter range. This leads to a basic problem that has to be solved during the development of the required NDT instrument, since the wavelength of the penetrating signals can become larger than the phenomenon being measured. Another basic problem that has to be solved is that corrosion product and acoustic or electromagnetic wave interaction relationships needed to infer materials strength and remaining life are not well understood.

PHASE I: Select and justify the most appropriate NDT technology to permit in situ single sided measurements on civil structures, develop theoretical and mathematical models to predict strength and remaining life based upon details in signals modulated by corrosion products or loss of material, investigate optimal wave shapes to produce the greatest signal change when the wave interacts with corrosion products/material loss, and prepare preliminary hardware and software designs for a field instrument (including sensor concept designs to generate and detect the necessary signals).

PHASE II: Produce a prototype NDT field instrument based upon the preliminary hardware, software and sensor designs resulting from Phase I. Test the functional measurement capability of the instrument on model structures containing controlled defective strengthening steel elements of various types, and refine the hardware, sensors and software as necessary to obtain accurate remaining life data. Demonstrate the operation of the refined field instrument on at least three reinforced concrete structures, with the specific objective of proving that useful engineering data can be obtained in the field under real operating conditions.

PHASE III: The military and commercial applications include prestressed concrete bridge decks, post-tensioned concrete bridge girders, dam tainter gate trunnion bearing anchorages, as well as steel elements used in reinforced concrete structures such as tunnels, hardened structures, and bunkers. The non-DOD users include state DOTs, construction engineering companies, and consulting engineers.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Maintenance of reinforced concrete structures is presently very costly, because it is labor intensive and subject to regulatory oversight due to the high reliance upon visual and radiographic inspections. The proposed NDT instrument will eliminate regulatory oversight and significantly reduce the logistic requirements for frequent visual inspections, since quantitative results related to remaining life will be produced. In addition, there will be improved readiness and increased safety by giving civil engineers a better means of assessing the structural integrity of bridges and dams.

REFERENCES:
1) Mester, M.L., and McIntire, P., "Nondestructive Testing Handbook Volume 4, Electromagnetic Testing," American Society for Nondestructive Testing, Columbus, OH, 1986.
2) Miller, R.K., and McIntire, P., "Nondestructive Testing Handbook Volume 5, Acoustic Emission Testing," American Society for Nondestructive Testing, Columbus, OH, 1987.
3) Berks, A.S., Green, R.E., and McIntire, P., "Nondestructive Testing Handbook Volume 7, Ultrasonic Testing," American Society for Nondestructive Testing, Columbus, OH, 1991.
4) Nishida, S., "Failure Analysis in Engineering Applications," Butterworth-Heinemann, London, 1992.

KEYWORDS: nondestructive testing, remaining life prediction, corrosion detection, bridges, dams

A01-147 TITLE: Electrostatic Dehumidification Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To investigate, analyze, design, develop and test electrostatic dehumidification process. A novel, energy efficient dehumidification system with minimal field maintenance requirement will be developed.

DESCRIPTION: This project is to develop a dehumidification system with simple mechanisms and minimal maintenance requirements. The electrostatic collection and removal of water molecules presents a novel and energy-efficient method for dehumidification. The electrostatic dehumidification is based on the principle that a water molecule will experience an electrostatic force [1] when in the presence of a strong electric field gradient, will migrate in a certain direction, and be removed from the air stream. Note that a water molecule under a uniform electric field will just align itself with the field and not move towards one electrode or the other. However, in the presence of a non-uniform (gradient) electric field, molecules possessing a dipole moment will experience a force driving the molecules toward an electrode. A simple model has been discussed in the Reference [2], and experimental observations have been reported in the References [2-4]. Further, if the water molecule (or collection of molecules, such as a water droplet) becomes electrically charged, the driving force will be significantly increased. A theory of similar phenomenon [5] has been rendered into commercialized pollution control devices on smoke stacks. Dehumidification is an important engineering process with wide applications. A particular example is space humidity control for a storage facility in the field with minimal maintenance requirement. Conventional dehumidification technologies include condensation of moisture through cooling the air stream below saturation temperature or adsorption of water molecule by chemical desiccant material. The vapor condensation process utilizes mechanical cooling that is energy intensive. The desiccant dehumidification requires regeneration cycle, which is also energy intensive and mechanically complex.

PHASE I: Investigate and analyze the electrostatic dehumidification process for a bench-scale test system. Refine or revise a theoretical model describing the motion of a water molecule in a strong electric field gradient as discussed in Reference [1]. Identify governing parameters responsible for the motion of water molecules. Formulate a qualitative relationship between the energy requirement and the mass of water collected and removed. Demonstrate a bench-scale test system based on the electrostatic dehumidification process.

PHASE II: Develop and demonstrate a prototype electrostatic dehumidification system. Develop a quantitative model for system design and construction. Design and build a prototype system based on the developed design criteria and construction specifications. Field test the prototype system for a selected Army application.

PHASE III: Commercialize electrostatic dehumidification systems. The energy efficient and cost-effective removal of moisture from the air stream is critical in air-conditioning the private sector buildings as well as the DoD facilities. Industrial specifications will be developed based on the field performance data from the PHASE 2. During the PHASE 3, industrial partners will be identified to manufacture the electrostatic dehumidification systems on the commercial basis.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The inherent simple mechanism and energy efficient process of the electrostatic dehumidification system will be a significant benefit for space cooling applications, including for humidity control in the field. Absence of moving parts in the electrostatic dehumidification system will greatly reduce the system maintenance requirements.

REFERENCES:
1) Dielectric Materials and Applications, edited by Arthur von Hippel, pages 28-36, Artech House, Boston & London, 1995.
2)"A Novel Dehumidification Technique Using Electric Field," M. Arfi-uz-Zaman, M. Rezwan Khan, A. K .M. Sadrul Islam, and Fayyaz Khan, IEEE Transactions on Industry Applications, Vol. 32, No. 1, January/February 1996.
3) "Rapid Evaporation of Water from Surfaces," Hoenig, S., A2C2, pp. 15-17, July/August 2000.
4) "Field Experiments of an Electrostatic Fog-Liquefier," Uchiyama, H., and M. Jyumonji, Proc. ESA-IEJ Joint Symp. Electrostatics, p.p. 97-104, 1994.
5) Fluid Dynamics of Multi-phase Systems, Soo, S. L., Blaisdell, Waltham, MA, 1967.

KEYWORDS: Electrostatic dehumidification, air-conditioning, energy conservation.

A01-148 TITLE: Development of Field Opacity Measurement Device

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objectives are to develop a device that measures/analyzes the real-time opacity of particulate matter (PM) plumes at Army unique training sites and to develop a sampling protocol to use this device. The real time opacity measurement results will be used as Army Installations environmental compliance data for the states regulatory agencies.

DESCRIPTION: Army training activities generate PM emissions that can be major contributors to poor local and regional ambient air quality. There is a critical need to accurately measure/analyze the opacity of PM plumes caused by Army training activities. Plume opacity is defined as the amount of visible light extinction that occurs through a transverse section of a plume. The plumes may contain both geologic materials and chemical constituents of smokes and obscurants compounds used during training. The plume cross section can vary from tens of meters to half a kilometer. The current method of determining plume opacity is for a qualified human observer to assess the opacity of the plume against the background of the sky. The details of this method are presented in the U.S. Environmental Protection Agency Method 9 (40CFR60, appendix A). The results of this method are rather subjective since they are based entirely on human observation and there can be disagreements between Army and regulatory opacity determinations. An automated opacity measurement system would prevent disagreements by greatly reducing human error since it would not require specially trained operators. The required technology for measuring plume opacity either does not exist or does not meet the requirements of the Army as stated in the Army Environmental Compliance User Requirement A (2.1.b). This requirement calls for measurement systems that are portable, affordable, capable of measuring and recording data in real time, and capable of operating continuously for up to eight hours. The opacity measurement devices will probably either directly measure light extinction through a plume using a visible light transmitter and receiver or indirectly measure light extinction by measuring the contrast of the plume against the sky or some other background. The opacity measurement system must account for light extinction caused by both scattering and light absorption within the plume, although scattering is the primary contributor in most cases. Possible solution technologies include, but are not limited to, the following: transmissometer, nephelometer, opacity camera, and light detection and ranging (LIDAR). However, existing systems using these technologies are designed for fixed PM sources; they are expensive, large, not portable, and without real time/continuous measuring capability.

PHASE I: Demonstrate and document the capabilities and feasibility of the new PM measurement technology by building a laboratory scale prototype and testing it under a large number of potential field conditions. The work during this phase must not only demonstrate measurement capabilities but also the potential for achieving the other attributes discussed in the Description. Test plumes must mimic those generated from Army training activity and should include fog oil and soil based plumes.

PHASE II: Develop a production scale prototype of the measurement system developed in Phase I and test it on PM plumes in the field. Again, the plumes need to include both fog oil and soil based plumes. Prior to Phase II testing, develop a testing protocol that discusses the operational procedures of the equipment, the goals of the testing, and the experimental design. Document all testing results and conclusions in a technical report.

PHASE III: Successful development of this new measurement technology will create a tool useful for measuring PM emissions from many military sources. Commercial applications will include PM measurements in the mining, construction, and agricultural industries.

REFERENCES:
1) Code of Federal Regulations (CFR), title 40, part 60, appendix A, Method 9, "Visual determination of the opacity of emissions from stationary sources"
2) Seinfeld, J.H., Atmospheric Chemistry and Physics of Air Pollution (John Wiley & Sons, 1986).

KEYWORDS: opacity, particulate matter, air pollution measurement, size distribution, training.

A01-149 TITLE: Multi-frequency Radiometer Inflight Icing Detection System

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a small, lightweight, and inexpensive microwave radiometer system for placement on helicopters, commuter and private aircraft, including small aircraft such as Unmanned Aerial Vehicles (UAVs), to determine if icing conditions exist along the flight path. The system should determine if 1) clouds are all ice, all liquid, or mixed phase, 2) the differential integrated liquid water along the path, 3) if the cloud liquid water is supercooled (temperature colder than 0°C), and 4) whether drizzle size (500 mm) or larger drops exist. The radiometer may use multiple frequencies to assess cloud condition ahead of the aircraft using brightness temperature and polarization information, and should operate successfully from within cloud as well as from outside cloud.

DESCRIPTION: Small, robust microwave radiometer systems that are capable of being mounted on small, UAV-like aircraft and helicopters to detect cloud-icing conditions remotely along the flight path are not available. The Federal Aviation Administration promotes only radar for this application, but passive microwave radiometry is superior for DoD remote ice detection applications because it is not detectable by targeting devices, and is low in cost and small in size and power requirements. A multiple frequency, airborne microwave radiometer is needed that utilizes both brightness temperature and polarization measurements to retrieve information that can be used to predict an icing metric, and will operate within and outside of clouds. The system should be relatively inexpensive, require low power, occupy a small volume in the aircraft nose or leading edge of a wing, and be lightweight. The system will ultimately be used for detecting icing conditions using brightness temperature and polarization ahead of the aircraft. Antenna diameter should be no larger than 13 cm to have a form factor that will mount on a small aircraft and yet have a relatively narrow beam. An accurate dual linear polarized antenna is necessary with good polarization purity to allow accurate calibration and for making polarization measurements.

PHASE I: Develop a breadboard model that will demonstrate the feasibility and capability of multi frequency, multi-channel (H and V brightness temperature) system. The system should have a narrow main beam, two polarizations (horizontal and vertical), and two frequencies (30-40 GHz and 89-90 GHz). The brass board system should be testable in the field (not necessarily on an aircraft) at the end of Phase I and provide brightness temperatures and polarization information. The system should provide a minimum of three, and optimally four, Stokes parameters, if feasible.

PHASE II: The prototype should be a finished, ready-for production product that can be placed on a variety of small military or civilian fixed or rotary-wing aircraft such as UAVs being developed for the Army's Objective Force Capability. The system should be hardened for military use, should be able to operate in a wide range of environmental conditions, and should provide brightness temperature and polarization information that can be used for determining icing conditions. The system should not be considered a UAV payload replacement, but as an adjunct to payloads already on the aircraft for surveillance, communication, and target recognition and acquisition. The system should be demonstrated on a variety of aircraft, and provided to the government for testing.

PHASE III: The proposed microwave radiometer system enabling icing conditions to be detected ahead of aircraft will serve both military and civilian applications. Helicopters and UAVs are susceptible to icing because of their low flying speeds, requirement to loiter at low altitude, and unique aerodynamics. Commercial commuter aircraft, and light, private, unpressurized aircraft also fly primarily at slower speeds at lower altitudes (< 20,000') where icing conditions are most prevalent. In addition, helicopters, UAVs, and private aircraft typically do not have onboard ice protection systems making them vulnerable to trace and light icing. A small, lightweight, low power, and inexpensive microwave radiometer system provides needed stealth for military operations, can be placed on small aircraft, and is of sufficiently low cost to be affordable by nearly all aircraft operators.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The proposed radiometer system will allow algorithms being developed by the Army to be used on aircraft to avoid icing conditions. This will allow improved readiness and high utilization of current aircraft by allowing them to fly rather than be grounded and avoid icing conditions for enhanced in-flight safety.

REFERENCES:
1) Ryerson, C., 2000, Remote Sensing of In-flight Icing Conditions: Operational, Meteorological, and Technological Considerations. ERDC/CRREL M-00-1, NASA/CR-2000-209938, 75 p. available at (http://www.crrel.usace.army.mil/library/pub00fyo.htm#CRREL%20Monographs)
2) Ryerson, C., G. Koenig, A. Reehorst and D. Pace, 2000, "Ground-Based and Airborne Remote Sensing of Inflight Aircraft Icing Conditions," in Proceedings of the 2000 Advances in Aviation Safety Conference, P-355, Daytona Beach, Society of Automotive Engineers, pp. 165-172.

KEYWORDS: multiple frequency microwave radiometer, polarization, UAV, clouds, liquid water, temperature, small aircraft, inexpensive

A01-150 TITLE: Accurate Real-Time Spatial Coordinates for Hand-Held Sensors Used in Rough-Terrain UXO Cleanup Sites

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design, fabricate, and demonstrate a prototype digital system that tracks and records the 3-D spatial coordinates of any hand-held sensor being used to detect and/or discriminate unexploded ordnance (UXO) in difficult terrain conditions. These spatial data would enhance the ability of site coordinators to map suspected UXO and would allow cleanup crews to return to the precise locations of suspected UXO and to minimize the effort required to recover each UXO item.

DESCRIPTION: During the 31 Oct - 1 Nov 2000 UXO Program Development Workshop held at the Environmental Laboratory of the USAERDC - Vicksburg Site, participants agreed that one of the most pressing needs for crews at UXO cleanup sites is that of being able to accurately record the location of each suspected UXO item, particularly when hand-held sensor systems are being used in rough or heavily-vegetated terrain. Differential ground positioning system (GPS0 has been effectively integrated into vehicle-mounted and vehicle-towed UXO sensor systems to map anomalies at relatively smooth and sparsely-vegetated cleanup sites. However, the only means of locating potential UXO in ditches, gullies, and brush and tree-covered terrain or any other site conditions that necessitate the use of hand-held sensors is the classic "mag and flag" procedure. Steep terrain slopes, tree canopies, and even the human operator can block the GPS satellite from being able to "see" the UXO sensor. To make the UXO cleanup operation cost effective in such terrain, the cleanup crews need to be able to rapidly sweep the area with hand-held sensors and continuously record both sensor data and sensor position data so that accurate maps UXO locations can be generated. This would allow the crews to easily return to those UXO coordinates and extract the item from the ground with a minimum of effort.

PHASE I: Conduct an evaluation of both existing and innovative technologies for locating moving targets that could be applied to a rough and/or vegetated terrain. Existing technologies might include (but are not limited to) acoustic, microwave or radio wave, laser beam or accelerometer elements. Obviously, if line-of-site devices are used, it is expected that an array of such devices would be required. A prototype position-monitoring system will be fabricated and its use demonstrated in a hand-held mode without an associated UXO sensor and in any terrain condition that the contractor chooses. Acceptable results will consist of digital 3-D positional data of a hand-held item that serves as a surrogate of any state-of-the-art electromagnetic induction device that could be used to locate potential UXO. Accuracy should be better than a five centimeters.

PHASE II: Fabricate and demonstrate a practical position measurement system in a terrain condition chosen by the monitoring agency. This site will include trees, shrubs, and/or sharp elevation changes and will include a surface area of about two hectares. The device will be integrated into a state-of-the-art UXO sensor, and the contractor will produce a spatial map of potential UXO sensor signatures. Those signatures will come from metallic devices emplaced by the monitoring agency.

PHASE III: Army Training Ranges - UXO Remediation

REFERENCES:
1) Thomas Bell and Jonathan Miller, "Effects of Positioning Errors on Broadband EMI Data Inversion", Partners in Environmental Technology Technical Symposium & Workshop, Nov 28-30, 2000, Arlington, VA
2) Department of Defense, The Joint Unexploded Ordnance Clearance Steering Group's 1997 Report to Congress, Unexploded Ordnance Clearance: A Coordinated Approach to Requirements and Technology Development

KEYWORDS: unexploded ordnance (UXO), position measurement devices, vegetated terrain, acoustic, microwave, radio wave, laser beam, electromagnetic induction

A01-151 TITLE: Statistical approaches to provide accurate toxicity estimates from exposure data utilized in risk assessments.

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an approach for obtaining probabilistic concentration and exposure threshold values of toxicity for contaminants of military interest based on existing laboratory-based toxicity and bioaccumulation data. The focus of this work effort is to develop validated statistical approaches to determine the uncertainty surrounding exposure based toxicity estimates for subsequent use in the conduct of risk assessments.

DESCRIPTION: Currently, risk assessments for Military Unique Compounds (MUCs) are being conducted using limited toxicity data resulting in unacceptable levels of uncertainty. Evaluating the environmental consequences and ecological risk of contaminant bioaccumulation and exposure is a complex technical and regulatory problem (Bridges et al. 1996). In part, this complexity results from the fact that bioaccumulation is a measurable phenomenon, rather than an effect. Merely identifying the presence of a chemical substance in the tissues of an organism is not sufficient information to conclude that the chemical will produce an adverse effect. All chemical substances have the potential to produce adverse effects (i.e., toxicity), including such diverse compounds as nitroaromatic, polyaromatic hydrocarbons, and heavy metals. The likelihood that a chemical substance in the tissues of an organism will produce an adverse effect is a function of the physical and chemical properties of the substance, the concentration of the chemical in the tissues of the organism, and the length of time the organism is exposed to the compound. Because environmental contaminants vary so widely in their potential to produce toxicity, contaminant-specific information must be used to reach a determination regarding the potential for a bioaccumulated substance to produce adverse effects.

Databases, such as the Environmental Residue Effects Database (www.wes.army.mil/el/ered), contain residue-effects information on many environmental contaminants of potential concern. However, there is limited data and data points for MUCS and as a result, there is a large degree of uncertainty using these residue-effect values. A more accurate assessment of toxicity associated with chemical exposure (estimated using a body burden) would prevent the unnecessary economic burden on the military due to overestimating risk, or conversely, prevent adverse ecological effects by underestimating the risk associated with a chemical exposure. Therefore, a statistical approach is needed to utilize these limited data sets for MUCs while decreasing the uncertainty associated with these body-residue based toxicity estimates.

PHASE I: Review and identify potential statistical approaches that may be used to estimate concentration-based toxicity thresholds from existing toxicity and bioaccumulation data sets. Once the most likely candidate statistical approaches are selected, an evaluation will be conducted on these selected approaches using existing comprehensive data sets for MUCS for which body-residue toxicity threshold values can be determined with a high degree of confidence.

PHASE II: Test and validate appropriate selected statistical approaches for MUCs where existing toxicity and bioaccumulation data are limited. Criteria for appropriate models should include the confidence of values determined, as well as an ability to characterize the uncertainty surrounding the estimate.

PHASE III: The approach will be valuable for use at Army installations and training ranges as well as civilian applications such as environmental evaluations required in the USACE dredging program. The model would also have applications outside the DOD such as the Superfund Program (U.S. EPA), state environmental monitoring and regulatory programs, and any agencies conducting ecological risk assessments.

REFERENCES:
Bridges, T.S., Moore, D.W., Landrum, P., Neff, 1, and Cura, J. (1996). "Summary of a workshop on interpreting bioaccumulation data collected during regulatory evaluations of dredged material," Miscellaneous Paper D-96-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS.

KEYWORDS: Risk assessment, body-residue, toxicity, statistical approach

A01-152 TITLE: Rapid Response Waste Management in Support of Contingency Operations

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Research, design and build both the hardware components of an integrated waste management system for rapid response contingency operations in support of national interests and international crisis. Product will be used to support soldier deployment and natural disaster response by facilitating waste accumulation and treatment or disposal to facilitate human health protection and environmental stewardship in these contingency operations. System should be air deployable, self contained and modular allowing for unlimited support capability.

DESCRIPTION: Providing infrastructure support rapid response actions where host nation infrastructure is insufficient to maintain operations presents human health challenges and environmental concerns for deployment of military and civilian personnel in support of contingency operations.

Military personnel confront this problem on a regular basis, whenever deployed on a contingency operation to an underdeveloped nation. Efficient mission planning and execution is inhibited until suitable and sustainable infrastructure exists to preclude health and environmental concerns.

The complexity of sustainable non-war operations is inversely related to the level of infrastructure development in the assisted nation. The complexity of the problem is increased by lack of knowledge concerning local environmental laws regulations or customs requiring timely or costly negotiations further inhibiting the immediate installation of necessary waste management infrastructure necessary to support large scale non-war contingency operations.

To ensure that the system provides sufficient waste handling capabilities, the following requirements must be met. The equipment must be capable of handling waste streams consisting of 1) Grey water, 2) unused or discarded petroleum, oil, and lubricants (POL), 3) routine trash, and 4) mess wastes such as fats oils and grease (FOG) and discarded food. The equipment will be mobile and once positioned within area of operation it must be easily repositioned within a 100 mile radius in 24 hours without undue transportation assets. The equipment will be modular enabling customized configurations that support crisis specific operations and enhance existing services to preclude providing unnecessary redundancy in the area of operation. The equipment will be self-supporting in that it will contain it own power supply yet be compatible with other equipment in the US Army inventory. Wastes or residues generated will be benign to the environmental and safe to handle by equipment operators. This capability will facilitate interpretation of the dynamic aspects of the problem.
To ensure that the system is practical it must 1) be portable, 2) have low set up time, 3) have low operation and maintenance requirements (O&M), and 4) require limited transportation assets to deliver it to areas of crisis.

PHASE I: Conduct feasibility investigation, select the most appropriate technology, prepare a preliminary hardware design, and a preliminary O&M description to include routine maintenance cycle and required replacement parts. The feasibility investigation must describe at least three alternative technologies and it must explain the advantages of the selected technology, relative to those that were considered and were then dismissed. Preliminary hardware design must include an approximate cost of production, a description of any safety hazards, and an explanation of any availability issues related to equipment components. Preliminary O&M description must include preliminary set up instructions for individual modules as well as for integrated system applications, approximate crew requirements, equipment maintenance cycle with necessary down time, and replacement parts requirements.

PHASE II: Prepare final design and construct working model(s). Demonstrate the model with representative waste streams. Refine the hardware and software components as deemed necessary from the demonstration.

PHASE III: This system would be useful for both military and civilian lead crisis response actions taken by the federal government. Civilian examples include Federal Emergency Response Agency (FEMA) actions, state emergency response actions, and United Nations response actions in support of natural disaster.

KEYWORDS: waste control, contingency operations, waste treatment, environmental compliance, base support, installation support

A01-153 TITLE: <u>Electro-Osmotic Pulse Technology to Control Leaching and Groundwater Intrusion in Containment Sites</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an economically feasible prototype seepage prevention system based on electro-osmotic pulse technology to be used primarily in landfill and hazardous waste containment applications.

DESCRIPTION: Electro-osmosis is the transport of cations due to the application of an external electric field. Because of the molecular binding nature of water molecules, water molecules are transported along with the cations. This technique has been used in civil engineering to dewater dredgings and other high-water content waste solids, consolidate clays, strengthen soft sensitive clays, and increase the capacity of pile foundations. Electro-osmosis has received significant attention in the last 5 years as a method to remove hazardous contaminants from groundwater or to arrest water flow. Although results have shown the technique to be feasible, they have not been remarkable. One limitation of the present application is the use of a constant direct current, not a pulsating current. Currently, electro-osmotic pulse (EOP) technology is being applied to concrete structures. A system has been developed that uses a pulsating direct electric field. The system consists of an electronic control unit that delivers electric pulses to positive electrodes (anodes) inserted into the concrete structure. The negative electrode (cathode) is driven into the exterior soil or buried within the concrete structure outside of the protected area. The pulsating electro-osmosis system consists of a pulse of positive voltage (as seen from the dry side of the concrete wall) and a period of rest when no voltage is applied. The pulse of positive voltage has the greatest duration and amplitude. The electrical pulse causes cations (e.g., Ca^{++}) and associated water molecules to move from the structure's dry side towards the wet side, counter to the direction of flow induced by the hydraulic gradient, thus preventing water penetration through buried concrete structures. By using a pulsating excitation; electrode polarization, cation depletion, and overdrying of the concrete are prevented. The application of pulsating electro-osmosis and semi-conductive anodes to soils may overcome some of the limitations of the present direct current method.

PHASE I: A theoretical model detailing the similarities and differences in the application of the EOP system to soil compared to those previously used in concrete would be developed. The theoretical developments would be complemented by small and large scale laboratory testing. Some issues to be addressed are: optimization of the pulse pattern for various soils and contaminants, e.g. number of cations available, and; selection of anode and cathode materials based on soil and contaminant type.

PHASE II: The design construction and installation of three full scale prototype systems would be completed, based on the previous phase I design work. The test sites would include a normal landfill, a hazardous waste containment site, and a remediation barrier site. Prior to system installation, guidelines would be developed for applicable sites, operating procedure and monitoring, installation methodology and technical specifications, and reliability monitoring.

PHASE III: The technology for seepage prevention system is applicable to landfills and hazardous waste containment applications within the DoD, other Federal agencies, State agencies and private sector foundations. There are extremely high benefits in terms of cost savings through this environmental technology.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: A proven and economic seepage prevention system will decrease the expense of new construction and/or add additional insurance in the form of backup containment enhancement. For existing landfills and containment applications, many of which are near or beyond their design life, this easily retrofitable system will help to avoid increased future liability (i.e., clean expenses per site of $200K to $100M and more). This technology also has potential for use in emergency spill response situations

REFERENCES:
1) K. Utklev, "Method and Apparatus for Controlling the Relative Humidity in Concrete and Masonry Structures," U.S. Patent No. 5,368,709.V.F. Hock, M.K. McInerney, and E. Kirstein,
2) "Demonstration of Electro-Osmotic Pulse Technology for Groundwater Intrusion Control in Concrete Structures," FEAP Technical Report 98/68, U.S.
3) Army Center for Public Works, April 1998.M.K. McInerney and V.F. Hock, "Electroosmotic Pulse Technology for Groundwater Intrusion Control in Concrete Structures, presented at the 21st Army Science Conference held 15-17 June, 1998 in Norfolk, Virginia.

KEYWORDS: electro-kinetics, historic, masonry, moisture, structures, water

A01-154 TITLE: Network Centric Interoperability

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO, Air and Missile Defense

OBJECTIVE: To research and develop technologies that will benefit Army and Joint Interoperability in terms of (but not limited to) reduced data latency, increased processing efficiencies, improved bandwidth utilization, and/or other technical performance measures (TPMs) that quantify benefits to battlefield interoperability from a network centric perspective.

DESCRIPTION: Current Army and Joint interoperability efforts focus on system-centric development and implementation of technology to exchange data and derive information for individual systems' command and control to execute their respective mission(s). In this approach, interoperability is developed from each system's perspective and changes/improvements are implemented as separate, individual system changes. This results in system-unique interpretations/ implementations of Joint communications standards that seldom approach optimum/intended interoperability performance. For Joint Interoperability to achieve envisioned levels of performance and consistency between systems' implementations, its research and development requires a change in perspective to one that is network-centric. In a network-centric paradigm, systemic technologies/ concepts/ solutions will be developed to better integrate, support, and enable symbiotic battlefield interoperability of Army and Joint systems to function at or near optimal performance and warfighting capability.

Network Centric Interoperability (NCI) leverages data, information, and knowledge processing technologies and integrates systems' capabilities into solutions for real-time battlefield needs. NCI is the domain in which "lock-in" capable solutions are being developed for Army and Joint implementations of the Information Grid described in Network Centric Warfare (NCW) [Cebrowski and Garstka, 1998; and Alberts, Garstka, and Stein, 1999].

This solicitation seeks technology research that will ultimately benefit Army and Joint Interoperability by providing new, innovative, and creative systemic solutions to interoperability problems/issues and improvements to the current state-of-the-art while meeting Army and Joint requirements for timely, highly reliable, and secure interoperability. Proposals should focus on one or more of the following approaches to NCI technology research: (1) new technologies, (2) crossover application(s) of modern technologies, (3) new analysis tools/ techniques/ algorithms, or (4) new/alternative interoperability practices and procedures (IPPs).

Examples of new technologies that could be applied to NCI would include the following:
- New data/information processing techniques,
- New transmission protocols and/or formats,
- New information protocols implemented over current or new transmission media.

Examples of crossover applications of modern/commercial technologies that can be applied to the benefit of Army and Joint interoperability include the following:
- Internet technologies,
- Network technologies (e.g., local and wide area network technologies), or
- Technologies to enable the tactical internet to support battle management, command, control, communications, and intelligence (BM/C3I).

Examples of new analysis tools/techniques/algorithms would include the following:
- Technologies to transform analysis capabilities from post-processing into real-time,
- Parallel software or non-intrusive measurement techniques to provide the following:
  • New and innovative analytical processes (viz., new TPMs for interoperability),
  • Real-time analysis of content and performance of communications, and
  • Diagnostic/prognostic capabilities for Army and Joint Interoperability.

Examples of new/alternative IPPs would include the following:
- Alternative or augmented communications standards or technologies for legacy systems that would allow interoperability with modern protocols/formats/media,
- Network planning tools and techniques that will improve the robustness of network plans for possible battlefield situations and environments, or
- Network analysis capabilities that will allow dynamic network changes (either preplanned or real-time) that increase communications reliability and bandwidth utilization, ensure timely delivery of critical data/information, and/or reduce data latency.

Proposed research must quantify its benefits to Army and Joint Interoperability in terms of appropriate TPMs such as reduced data latency, increased processing efficiencies, improved bandwidth utilization or other interoperability TPMs (to be specified/proposed in the response(s) to this solicitation).

PHASE I consists of investigating the potential benefits, estimating the probability of success, and evaluating the risk of the proposed research topic. Deliverables in Phase I should describe the proposed topic's merits and feasibility and quantify technical data and information that supports consideration of potential impacts to current US Army and Joint Service Interoperability capabilities. A demonstration of the proposed technology's performance must be planned and proposed for Phase II to be conducted with the systems resident/represented in the US Army AMCOM Software Engineering Directorate's Interoperability, Engineering, and Test (IET) Laboratory.

PHASE II consists of the demonstration or prototypical deployment of the proposed topic/technology. During this phase, demonstration of the proposed topic will be conducted with the systems resident/represented in the US Army AMCOM Software Engineering Directorate's IET Laboratory. This demonstration shall include estimates or measurement of appropriate TPMs that will substantiate the technology's merits and feasibility and provide for collection of the statistical performance data to support implementation risk evaluation. Phase II deliverables must quantifiably substantiate the benefits and risks to improve Army and Joint Interoperability into a NCI implementation of the NCW Information Grid.

PHASE III will leverage successes demonstrated in Phase II to benefit Army/ Joint/ non-DoD government/ commercial organizations. NCI research has broad dual use applicability that appears to be extensive in its number of applications as well as its scope and influence on commercial and civilian applications. Army and Joint military applications of this research include potential for incorporation into the Joint standards, practices, and procedures (subject to the discretion of the appropriate program office(s) and consistency with Army and Joint doctrine). Dual use extends well beyond military applications to include Government as well as commercial applications having requirements for fast, secure communications with high reliability in an environment with potential for jamming or interference. Examples of potential alternative applications / dual uses of technologies include the following:
- Networks of individuals' electronic devices that allow individuals to conduct business securely and reliably without unacceptable vulnerability to the threat of industrial espionage (viz., civilian and commercial applications and protection of US non-export technologies),
- Airport and Air Traffic Control networks linking commercial aircraft and airport navigational equipment to reduce risk of interference from terrorists or personal electronic devices being used by passengers (viz., commercial aviation and the Federal Aviation Administration applications),
- Networks of communication systems for emergency management personnel who need to simultaneously maintain situational awareness while managing the distribution of medical supplies, food & water services, and disaster relief during and after natural disasters or terrorist attacks (viz., Federal Emergency Management Administration)

REFERENCES:
1) "Network-Centric Warfare: Its Origin and Future", by Vice Admiral Arthur K. Cebrowski, U.S. Navy and John J. Garstka, Naval Institute Proceedings, 1998. [http://www.usni.org/proceedings/Articles98/PROcebrowski.htm]
2) Network Centric Warfare: Developing and Leveraging Information Superiority, 2nd edition (revised), David S. Alberts, John J. Garstka, and Frederick P. Stein, DoD C4ISR Cooperative Research Program (CCRP) Publication Series, 1999. [http://www.dodccrp.org/Publications/pdf/ncw_2nd.pdf]

KEYWORDS: Network Centric Interoperability, Joint Interoperability, Army Air and Missile Defense System Interoperability, Theater Air and Missile Defense Interoperability, Network Centric Warfare

A01-155 TITLE: Digital Television Exploitation

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: Unmanned Ground Vehicles Joint Program Office

OBJECTIVE: Apply the emerging DTV standards-based technology to a typical military imaging sensor communication link problem.

DESCRIPTION: By 2006, all television broadcasts in the US are mandated to be in the new Digital Television (DTV) standard format. The professional and consumer market for DTV encoding, transmission, reception, and decoding equipment will make DTV components available as Commercial Off-The-Shelf (COTS) components for military applications. Currently, many military sensor and imagery applications adhere to the older analog broadcast video standards to take advantage of commercially available, inexpensive video processing components. To capitalize on the emerging digital video state of the art, experience must be gained with this new technology, and challenges specific to military applications must be identified. Initial commercial DTV transmission equipment will focus on products to be used in studios, programming centers, and transmitter station environments, which have less-stringent size/weight/power constraints. The challenge will be to apply the encoding and transmission element of DTV technology to the more limited environments of missiles, Unmanned Aerial Vehicles (UAVs), manpackable systems, unmanned sensors, etc.

PHASE I: Design a communication system capable of supporting a substantial number of video formats defined under the overall DTV standard. Such a system will be capable of encoding, transmitting, receiving, and decoding multiple independent video data streams and other user defined data independent of the video streams. The encoding and transmission components of such a system should be compact enough to be included on board a missile, UAV, or other weapon system.

PHASE II: Develop and demonstrate a prototype DTV communication system capable of meeting weapon system size/weight/power constraints that maximizes the use of commercial DTV hardware.

PHASE III: The resulting miniaturized DTV encoding and transmission components would find wide acceptance in the news-gathering, mobile commercial broadcasting, and video security markets.

REFERENCES:
ATSC Digital Television Standard with Amendment No. 1 (16 Mar 00) (http://www.atsc.org/Standards/A53/)

KEYWORDS: "Digital Video", DTV, HDTV, Compression, Broadcast, ATSC

A01-156 TITLE: Small, Light, Inexpensive Control Valves for Fuel and Oxidizer Gels for Use in Gelled Bipropulsion Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Tactical Missiles

OBJECTIVE: Develop a high pressure Gel Propellant Valve (GPV) that has low weight, volume, cost and power requirements. This could be a bipropellant valve or two individual valves if both together would have equal or lower weight, volume, cost and power requirements. For the rest of this topic, a bipropellant valve will be assumed. The GPV will be coupled with an engine using pulse width modulation to vary the thrust level; therefore, it would be a simple on/off valve and does not require throttling.

DESCRIPTION: The key elements of this program are to analyze the requirements of a GPV (e.g. flow of a shear thinning fluid), design a simple, low cost, and small valve, fabricate and test the valve, and perform an analysis to project the cost of 5,000 units for 5 years. The GPV must be near flightweight (flight type) and designed to attach to an Aviation and Missile Command (AMCOM) vortex engine. The GPV must have a 20 ms stroke time or less with a leakage rate less than 1 drop per second of gel per minute at 3000 psi.

PHASE I: Develop innovative candidate GPV designs that break the paradigms of current valves, especially in the areas of simplicity, low manufacturing costs, low power requirements, and flow passages. The latter is particularly important since gels are shear thinning fluids and have different characteristics than liquids. Perform computational fluid dynamics analysis of the flow of AMCOM's baseline fuel and oxidizer gels through the candidate preliminary designs to determine the relative pressure drops. The range of the flow rates of the gelled propellants to be considered are 0.1 to 2 Kg/s (0.25 to 4 lbm/s).

PHASE II: Prepare engineering designs of the optimum GPV. Fabricate and test the GPV to characterize the pressure drop vs. flow rate relationship at –40, -25, -10, +10, +25, +35, and +45° C throughout the previously identified flow rate range. Perform engine tests coupling the GPV to a vortex engine to confirm the valve performance. Perform a manufacturing cost analysis to determine the expected price per valve at the previously defined rate.

PHASE III: Gel bipropulsion systems can be used by NASA on launch vehicles, spacecraft, and satellites. They are applicable for simple boosters as well as where variable thrust is required. The increased safety of gel engines can reduce the number of engines on spacecraft. For instance, a single engine could be used for changing from low to high earth orbits as well as precision positioning of the satellite for operational purposes, such as detecting leaking dams or mapping crop infestations. A novel valve design could also be used for any flow controlling applications such as petroleum production, chemical production, automobile and truck engines, and test facilities.

REFERENCES:
George P. Sutton, "Rocket Propulsion Elements: an introduction to the engineering of rockets," 6th Edition, John Wiley & Sons, 1992

KEYWORDS: Propellant Valves, Gelled Propellants, Gelled Propellant Rheology, Computational Fluid Dynamics, Unique Design

A01-157 TITLE: Polymer Microfabrication Techniques for Microelectromechanical Systems (MEMS)

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop processing techniques and materials that allow rapid, low cost fabrication of microelectromechanical systems (MEMS) components and integrated MEMS through materials and methods other than traditional semiconductor processing.

DESCRIPTION: MEMS processing technology is rapidly advancing to the point where complex sensors and microoptical systems will soon be available that offer significant capability increases compared to traditional sensors and optics. However, many of the processes used depend on expensive semiconductor equipment and facilities. These processes are also, for the most part, limited to silicon-based materials and geometries in the sub- to low micron range. Some of the processing temperatures for MEMS devices are not compatible with electronic devices, thus a hybrid approach is usually used to interface the electronics with the MEMS. Approaches such as LIGA (Lithographie, Galvanoformung, Abformung) processing attempt to get around some of these limitations, but still require clean rooms, expensive equipment, and subtractive processes.

Polymer science has produced many formulations that are ideal for MEMS and electronics applications while providing easier and less costly processing. Stereolithography techniques for building 3-D polymer models from computer aided designs (CAD) have become commonplace, and universities have begun to extend resolutions into the micron range. Precision embossing of polymer films and laminates have also achieved very tight tolerances. Polymer materials development has produced organic materials that have semiconducting, photonic, and piezoelectric features. This topic endeavors to create a convergence of these processing and material technologies for the development of techniques that can be used to fabricate MEMS with advanced functionality on the surface of, and integrated into electronic substrates.

PHASE I: Investigate recently developed microfabrication and microforming techniques such as micro-stereolithography, micro-embossing, and microvia processing methods. These processes should be capable of producing 1 to 250 micron features over a large area (minimum 12"x12") substrate. Additive processes are more desirable than subtractive processes. Identify readily available and developmental polymers for processing using the previously stated methods. Some of these polymers should have ideal mechanical properties for actuators and cantilevered beams, while others should exhibit certain electronic properties to allow more sensitive sensors, more efficient electro-mechanical control, and greater integration with the substrate. The polymers should also have photosensitive and mechanical characteristics that match the specific microfabrication technique requirements. Microfabricate a series of simple prototype sensors that demonstrate the limits of the processing methods/materials and provide insight to the potential for MEMS device performance improvements and increased functionality/integration. Perform testing to determine functionality of the fabricated devices. Based on information gained through multiple fabrication/testing runs, downselect the materials and processes deemed to have the most promise with sufficient maturity to allow development of a stable prototype process by the end of Phase II. Device performance, material costs, processing costs, and expected yields should be considered in the downselect.

PHASE II: Modify off-the-shelf stereolithography equipment and refine micro-embossing tools to achieve efficient methods for microfabrication of low cost, high performance polymer MEMS devices. Investigate innovative methods for integrating polymer MEMS devices within the substrate electronics. Material/process compatibility are the major issues, and note polymers that are ideal for MEMS devices may also be satisfactory as electronic substrates. Investigate the possibility of fabricating multiple layers of devices within a single substrate. Perform device, substrate, and module tests to characterize achievements. Perform reliability testing such as Highly Accelerated Stress Test (HAST) and temperature cycling to demonstrate device and substrate robustness. Design and fabricate a "multiple-up" version of a stable design into a 12"x12" substrate for dicing and packaging. Investigate embossed features in the substrate that contribute to lower cost, efficient module packaging. Compare processing and materials costs for the developed techniques to standard MEMS silicon micromachining methods. Identify cost and performance benefits for the new techniques and develop a business case. Demonstrate a matured set of microfabrication processes in a beta-line fashion to encourage third party interest in further polymer microfabrication development and commercialization.

PHASE III: A Phase III effort will allow further increases in capabilities of the prototype equipment and processes and allow more complex devices and modules to be designed and fabricated for direct comparison to inorganic MEMS devices and modules. The potential market for low cost, easily producible sensors, actuators, and devices having photonic and micro-material processing functions is huge. Applications abound in the consumer, telecom, computer, and automotive industries, as well as the military. Commercial applications include interactive computer games via low cost inertial sensors, improved wireless phone performance through superior radio frequency (RF) MEMS devices, and faster fiber-optic network switching with MEMS-based optical switches. Military applications are numerous, with needs for miniature sensors, ranging from inertial sensors for missile and aircraft navigation, to vibration and chemical sensors for early warning and threat assessment, and improved RF and optical MEMS for improved radar performance.

REFERENCES:
1) "3-D Microfabrication Taps Photosensitive Resins", Electronic Engineering Times, Oct 00. Can be found at http://www.eet.com; search for "microfabrication".
2.) V.K. Varadan and V.V. Varadan, "Micro Stereolithography for 3-D MEMS", John Wiley & Sons, Inc., expected publish date: Dec 00.

KEYWORDS: MEMS, microfabrication, stereolithography, precision embossing, polymers

A01-158 TITLE: Compact Range Implementation of RF Target Glint Signatures for Multi-mode Hardware-in-the-loop Simulations

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PEO, Tactical Missiles

OBJECTIVE: The objective of this topic is the development and application of novel compact range techniques to multi-mode Hardware-in-the-loop (HWIL) simulations of millimeter wave (MMW), Infrared (IR), and semi-active laser (SAL) target signatures. In addition to generating the MMW target glint signals, the proposed technique must be compatible with a 5-axis motion simulator and also must include methods for folding in the IR and SAL bands. In addition to military uses, such technology would be applicable to many commercial uses involving the development and testing of collision avoidance systems and property protection systems.

DESCRIPTION: In the past, HWIL simulations of MMW target glint signatures have been implemented on a matrix array of triads of antennas located in the far field of the missile seeker system under test. These arrays are expensive and require large anechoic chambers to fulfill the far field requirement. It is desired to generate the glint signatures using lower cost compact range techniques in which a small array is imaged onto a reflector, producing a plane wave signal at the seeker aperture from each array antenna. In addition, this technique should allow more easily implemented options for folding in signals from the IR and SAL bands of interest. Also, the compact range will be mountable on a flight motion simulator. The individual array antenna signal amplitudes and phases must be controlled at up to 10 MHz rates to vary the instantaneous angle of arrival of the composite signal incident on the seeker antenna in synchronism with the seeker waveform sampling. A 1.0 GHz instantaneous bandwidth is required to accommodate wideband waveforms. A glint position accuracy of +/- 1.5 milliradians is required.

PHASE I: Explore the feasibility of developing a compact range system which meets the specifications above. Evaluate innovative technologies which may be used to build the system. Perform trade-off analysis to determine the best approach for each subsystem, and develop a preliminary design for the compact range system. Perform modeling and analysis to establish the proof-of-principle and predict the performance specifications for the final system.

PHASE II: Perform detailed design of the concept selected in Phase I, and fabricate a prototype compact range system. Demonstrate the SAL projector technology and characterize its performance in an actual HWIL environment.

PHASE III: Commercial applications for this technology might be found in the automobile, home security, and air craft industries. The novel compact range technique developed under this topic would provide an excellent test bed to support the development of single mode and multi-mode collision avoidance systems and intrusion detection systems.

REFERENCES:
1) Technologies for Synthetic Environments: Hardware-in-the-loop Testing, Proc. SPIE, Vol. 4027, April 2000.
2) Technologies for Synthetic Environments: Hardware-in-the-loop Testing III, Proc. SPIE, Vol. 3368, April 1998.
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KEYWORDS: Compact range, multi-mode, seeker, millimeter wave (MMW), infrared (IR), semi-active laser (SAL), hardware in the loop (HWIL), simulations

A01-159 TITLE: Advanced Control Concepts for Kinetic Energy Missiles

TECHNOLOGY AREAS: Weapons

OBJECTIVE: To develop technologies and concepts that enable control of kinetic energy missile systems without the attendant limitations and performance penalties of conventional control concepts such as aerodynamic fins/canards, jet reaction and impulsive thrusters.

DESCRIPTION: Hypervelocity missile concepts employing kinetic energy penetrators have the potential of providing the Army with overwhelming lethality against advanced armor, even those employing explosive reactive armor and next generation active protection systems. However, to fully realize this potential, kinetic energy missiles must be small and lightweight to be compatible with future combat vehicles as envisioned by the Army's transformation to a lighter, more deployable force. Also, for these kinetic energy missiles, the magnitude of the energy delivered to the target (and therefore the lethality) is limited by the missile aerodynamic drag and non-propulsive mass. These considerations place very stringent requirements and constraints on the missile design and in particular on the control actuation system, which is additionally driven to achieve high performance in terms of speed of response and output force. Conventional technologies for missile control all have attendant limitations and performance penalties with regards to aerodynamic drag and/or complex aerodynamic interactions, volume and weight. The objective of this effort is to identify, develop and evaluate new, non-conventional concepts for missile control, which reduce and/or eliminate those limitations and penalties. In particular, concepts for generating control forces by bending or otherwise modifying the airframe's aerodynamic characteristics in flight have been shown to be effective. Additionally, actuation concepts that employ so called "smart materials" such as piezo-electric, electro- or magneto-restrictive, and shape memory alloys are appropriate for this effort. It must be recognized that the advantages achieved by these control concepts are greatly dependent on the successful integration of the concept with all missile design disciplines including aerodynamics, structure, thermal, guidance, and propulsion. Therefore this effort will involve the development of and/or utilization of an integrated analysis and missile design environment for performing the required evaluation and optimization of specific concepts.

PHASE I: The result of phase I will be a control concept design which is shown to meet the performance requirements of a baseline kinetic energy missile and at the same time achieve significant improvements in one or more critical measures of aerodynamic drag, volume, or weight relative to a conventional control concept. These results will be demonstrated by analysis and simulation with laboratory performance validation data included for key components.

PHASE II: In phase II the conceptual design from phase I will be detailed and implemented in hardware for evaluation in the relevant environment. In this case, the relevant environments must include thermal, dynamic, and aerodynamic. The control concept prototype hardware will be integrated into a missile system physical simulator or breadboard to the extent required to fully quantify the performance and the effects of the environments.

PHASE III: Potential applications or insertion of this technology in phase III includes both military and non-military aerospace systems that require aerodynamic control at high mach number with minimum drag, volume, and weight. Examples applications are kinetic energy missiles, supersonic aircraft, reusable earth-space transportation vehicles, and helicopter blade control.

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1) Collar, Tinkler, "Hypersonic Flow", Some Aspects of the Design of Hypersonic Vehicles, 1960.
2) "Compact Kinetic Energy Missile Technology for Next Generation Army Direct Fire Weapon Systems", George W. Snyder, Albert K. Killen, and Stephen C. Cayson, 2000 AIAA Missile Sciences Conference, 08 Nov 2000

Keywords: hypervelocity missile, control actuation system, flexible airframe, aerodynamic control, smart materials

A01-160 TITLE: Combustible Particulate Gellant for Fuel Gels in Bipropulsion Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Tactical Missiles

OBJECTIVE: Develop particulate gellants for fuel gels in bipropulsion systems. Gellants must be identified for both MonoMethyl Hydrazine (MMH) and DiMethylAminoethylaZide (DMAZ) and produce gel formulations that are hypergolic with gelled Inhibited Red Fuming Nitric Acid (IRFNA). This gellant must easily combust with IRFNA such that neither the L* of the engine must be increased nor the nozzle exhaust plume have visible signature.

DESCRIPTION: The key elements of this program are to: 1) produce gellants for fuel gel formulations with MMH and DMAZ that have yield points of at least 60 Pa., 2) produce fuel gel formulations that do not produce greater than 206 KPa (30 psia) after storage at 60° C for 30 days; 3) characterization of the rheology (flow rate vs pressure drop and viscosity vs shear rate) from -40 to +45° C for a 3.2 mm (1/8") diameter 25.4 mm (1") long tube ; 4) characterize the performance (Isp, Pc) of the fuel gels with gelled IRFNA over an O/F mass flow rate ratio of 2.5 to 4.0 and chamber pressures from 10 to 20 MPa (1500 to 3000 psi).

PHASE I: Identify and/or synthesize a particulate gellant that will form stable fuel gels with the two liquid fuels. Demonstrate compatibility with 30 day, 60° C storage tests. Characterize the gel for the four standard quality control tests: density, centrifuge stability test (500 g acceleration for 30 minutes), yield point, and viscosity at a shear rate of 12,000 s-1. Characterize the rheology at -40° C, 20° C, and 45° C between shear rates of 10,000 s-1 and 300,000 s-1.

PHASE II: Characterize the rheology for both MMH and DMAZ gels at temperatures of –40, -25, -10, +10, +20, +35, and +45° C for shear rates between 10,000 and 300,000 s-1. Perform engine tests to fully characterize the performance for both MHH and DMAZ gels with IRFNA gel as described in the Description section. Prepare sufficient batches to create a two sigma statistical baseline of the four quality control tests of 10% or less for both MMH and DMAZ gels.

PHASE III: Gel bi-propulsion systems can be used by NASA for launch vehicles, spacecraft, and satellites. They are applicable for simple boosters as well as where variable thrust is required. The increase safety of gels over hyperglogic liquids decreases the hazards of manned space flights and ground operations. For instance, a single engine could be used for changing from low to high earth orbit as well as precision positioning of the satellite for operational purposes, such as detecting leaking dams or mapping crop infestations. Gellants for one application are often good gellants for others; therefore, a novel gellant may find applications for a wide variety of household and commercial gels from toothpaste to corrosion removers.

REFERENCES:
George P. Sutton, "Rocket Propulsion Elements: an introduction to the engineering of rockets," 6th Edition, John Wiley & Sons, 1992.

KEYWORDS: Gelled Propellants, Gellants, Combustion Efficiency, Gel Rheology, Compatibility, Rocket Fuels

A01-161 TITLE: Neural Network Reliability Prognostics Tool

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: National Missle Defense Joint Project Office (JPO)

OBJECTIVE: The objective of this SBIR is investigate and develop a neural network reliability prognostics model that can predict missile reliability based on individual missile environmental history.

DESCRIPTION: Missile system reliability is a statistically based science that is applied to a population of missiles which are assumed to be homogeneous. The assumption of homogeneity is becoming invalid due to differences in missile environmental history, and is also exacerbated by acquisition streamlining initiatives which result in different missile configurations. AMCOM currently develops statistical models based on missile performance to predict missile population reliability. AMCOM also has several programs to collect missile environmental data, but there is no way to accurately model reliability as a function of environment. It is desired to develop a reliability prognostics neural network software model to relate environmental history to missile reliability. The prognostics model should be able to accurately predict missile reliability as a function of the environmental history of a particular missile. Ultimately, the prognostics model should predict missile failure before it occurs. Finally, the model must be capable of being implemented on a standard computer workstation and/or PC.

PHASE I: This first phase is to determine feasibility and develop an initial neural network model for reliability prognostics. The SBIR team will evaluate the environmental data that is collected (or planned for collection) on missile systems, as well as existing missile reliability performance data such as missile firing reports and stockpile component testing. The SBIR team will determine whether the existing data is theoretically sufficient to develop a neural network model. Any deficiencies in the data will be noted. An initial neural network prognostics model will be developed at the missile system level. If necessary, this model will use "dummy" environmental data that is representative of actual field environments. Although data from specific missile systems may be used, the initial prognostics model is not intended to represent any particular missile system. Predicted model accuracy (i.e. predicted missile performance versus actual performance) should be at least 90%. Model run time on a workstation (or PC) should not exceed 2 hours per missile.

PHASE II: The second phase is to develop a limited prototype reliability prognostics neural network software model for a particular missile system. The missile system will be selected by the SBIR team based on the evaluation of data in Phase I. The prognostics model from Phase I will be tailored to the missile and extended to certain critical missile components (to be determined by the SBIR team) of the selected missile system. The complete prototype prognostics model should include system level and component level predictions, including selected missile performance parameters (selected by the SBIR team) as well as go/no-go predictions. Model accuracy should be validated against historical missile performance data. System level accuracy should be at least 90%, with a goal of 95%. Component level accuracy should be at least 80% with a goal of 90%. Model run time on a workstation (or PC) should be less than one hour per missile, with a goal of 10 minutes per missile.

PHASE III: This research and prototype model would provide evidence in the ability to predict the failure of a system through assessing the systems' environment, use, and age. The information provided by a neural network tool such as this could assist in many areas such as availability, spare replacements, and possibly prevent mission aborts. This type of predictive failure reporting model could be modified to fit other systems that have complex electrical and mechanical features such as airplanes and automobiles.

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1) Nachimuthu Karunanaithi, Darrel Whitley, and Yashwant K. Malaiya, Using Neural Networks in Reliability Prediction, IEEE Software Journal, July1992 p 53-59

2) Dragan KUKOLJ, Design of Supervisory Control Functions Based on FeedForward Neural Networks, Cybernetics and Systems:An International Journal, 2000 p749-761

KEYWORDS:
Prognostics, Nueral Network, software, Network capability

A01-162 TITLE: Extended, Transient, Rocket Exhaust Plume Modeling

TECHNOLOGY AREAS: Weapons

OBJECTIVE: To develop innovative models for the basic physical and thermochemical processes describing extended, transient, two-phase, gas-particle, chemically reacting rocket exhaust plume flowfields which can supplement the existing models which currently limit plume interference modeling.

DESCRIPTION: The recent development of a hypervelocity tactical missile employing command-to-line-of-sight guidance has revealed deficiencies in the existing methodology to predict rocket exhaust plume interference effects, particularly with regard to infrared laser guidance and long wave infrared target tracking. Simulation and analysis of the detailed physical processes associated with electromagnetic wave propagation through rocket exhaust plume flowfields in this application require field descriptions of the two-phase, gas-particle, flowfield over the entire trajectory from launcher to missile throughout the time of flight.

Computational fluid dynamic (CFD) models are available which account for the two-phase and finite-rate chemical kinetics processes in solid propellant rocket exhaust plumes with coupled body flowfields; however, these models, while very good, were intended to produce only quasi-steady snapshots of the missile flowfield along any point in the missile trajectory and then for only relatively short lengths as compared to the entire flight profile.
Conceptually, the existing CFD models could be run in piece-meal fashion over the missile flight trajectory perhaps in conjunction with a particle dispersion model to approximate the extended plume development process. However, it is unlikely that such a model could be used without considerable validation data to establish the model limitations.

As an alternate approximation, the existing CFD models could be run over a grid extending from launcher to missile in flight with the external flowfield velocity imposed as function of distance and time along the flowfield boundaries. Again, it is unlikely that such a model could be used without considerable validation and, furthermore, the computational memory and run time resources would likely be difficult to justify for such an approximate methodology.

Clearly a new and innovative modeling architecture is required to overcome the existing limitations. To be both practical yet adequate, the formulation of such an innovative and improved approach must give special consideration to the following:

1. The modeling architecture must incorporate the existing and extensive time -accurate, finite-volume, Reynolds-averaged, Navier-Stokes flowfield solution methodology including models for two-phase, gas-particle flows, and finite-rate chemistry.
2. Strongly coupled particulate interaction effects including turbulence dispersion and modulation.

3. The historically correct development of the extended plume flowfield over a prescribed trajectory including wind effects must be preserved for post-processing with selected plume interference models.
4. Intelligent processor control for domain decomposition among multiprocessors coupled with flowfield interrogation to identify the dominant physical processes at the local level and apply the most applicable solution methodology to each domain.
5. Dynamic and adaptive grid development to achieve adequate grid resolution both spatially and temporally to capture the flowfield features possibly using hybrid structured/unstructured grids as appropriate.
6. Fluid and chemistry time scales are incompatible with consequent stiff matrices and small solution time steps particularly over an extended plume flowfield.
7. Innovative solution techniques such that the required transient physical processes can be modeled while achieving solutions in a reasonable time period.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key transient plume flowfield problem areas, and (3) previous computational fluid dynamics experience in modeling two-phase, nonequilibrium gas-particle, chemically reacting flows with a CFD code possessing those capabilities.

Technical approaches will be formulated in Phase I to address the problem area for later inclusion into computational fluid dynamic models utilized by the exhaust plume community. At least one innovative architecture will be coded and exercised during Phase I to assess the potential for Phase II success.

PHASE II: The additional model improvements formulated in Phase I will be finalized, documented, coded, and incorporated into an existing Government computational fluid dynamics code. The improved computational fluid dynamics model will be run blind for a series of static solid propellant rocket exhaust plume test cases for which detailed infrared laser transmittance data is available to demonstrate the advanced capabilities for analyzing and modeling extended, transient, rocket exhaust plume flowfields.

PHASE III: For military applications, this technology is directly applicable to all command-to-line-of-sight guided missile systems. For commercial applications, this technology is directly applicable to environmental analysis techniques for applications such as high speed supersonic transports and aerospace launch systems.

REFERENCES:
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2) Snyder, G., "CKEM Technology," AIAA 2000 Missile Sciences Conference, 7-9 November 2000.
3) Dash, S.M., "CFD: Where can it take us?" Aerospace America, February 1992.

KEYWORDS: Exhaust plume, Computational fluid dynamics, Two-phase, gas-particle flow, Finite-rate chemistry, Turbulence models, Structured grids, Unstructured grids, Numerical methods

A01-163 TITLE: Innovative Technology Development for Lasar Radar (LADAR)

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop materials, devices, and packaging techniques that allow for the maturity level to be increase in laser radar sensors in missile applications.

DESCRIPTION: Compact imaging laser radar will likely have a key role in future autonomous systems from unmanned vehicle navigation to missile guidance due to the high resolution three-dimensional images that can be achieved. There are several critical areas in realizing high resolution range information. These include but are not limited to laser power and qulity vs packaging size, Detector responsitivity vs wavelenght, Singal detector vs Focal Plane Array, and Scanning vs non-scanning. To achieve less than 0.4 meter range resolution presumed necessary for reliable automatic target recognition (ATR), subnanosecond timing resolution is required. When laser pulse width is substantially greater than desired timing resolution, sophisticated signal processing is generally required. Additionally, in achieving sufficient peak power and narrow pulse width for high probability of detection and accurate range measurement, a compromise in laser pulse repetition frequency (PRF) is generally necessary. A low PRF limits the scan rate and area of coverage for an imaging ladar. To increase the area of coverage for a given scan rate, laser beam splitting and multiple receivers are typically used. In this case a Flash or Flood ladar could be used to increae frame rate. Proposals need not cover every aspect of a laser radar (LADAR) system design, but should contain enough information to make clear how the proposed component or technique fits into a LADAR scheme that is appropriate for imaging targets distance on the order of 1 Km or greater. Proposed schemes should be appropriate for implementation in at least a laboratory breadboard setup.

PHASE I: Examine material combinations, architectures and processes for constructing proposed system, with an emphasis placed on compact packaging. Identify candidate configurations, and perform trade studies to determine feasibility of each configuration identified. Propose a practical design that addresses the compact missile volume objectives and performance goals. Provide a detailed analysis/simulation to support the proposed design.

PHASE II: During Phase II a testable prototype will fabricated. This prototype component or Ladar system is based upon the design developed in Phase I. Test the device to stated performance objectives. Analyze the electrical noise characteristics, electrical power requirements, and cost drivers in fabrication process. Identify areas for performance enhancement, and fabrication cost reduction.

PHASE III: The Laser Radar technology and components developed under this SBIR effort would demonstrate enabling technology leading to availability of high resolution sensors presently restricted by eye safety issues associated with current solid state laser technology. Small light weight laser based sensors distinctly have both military and commercial applications including: range finding, remote sensing, and imaging laser radar.

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1) A. Jelalian, "laser Radar Systems," Artch House, Boston 1992
2) Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974
3) I. Melngailis, W.E. Keicher, C. Freed, S. Marcus, B. Edwards, A. Sanchez, T.Y. Fan, and D.L. Spears, "Laser radar component technology," in Proceedings of the IEEE, vol. 84, No. 2, pp.227-267, February 1996.
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KEYWORDS: Laser Radar (LADAR), Laser Ranging (rangfinder), Direct Detection, Pulse Capture, Laser, Dector, Scanning

A01-164 TITLE: Reliability Analysis and Project Tracking Environment (RAPTRE) Tool

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: National Missle Defense JPO (Joint Project Office)

OBJECTIVE: The objective of this SBIR is to determine the feasibility and develop a prototype for a Reliability Analysis and Project Tracking Environment (RAPTRE) model for use as an engineering decision making aid.

DESCRIPTION: Reliability analysis requires use of disparate pieces of knowledge and information that must be synthesized by the reliability engineer in order to make reliability engineering decisions and predictions. Furthermore, this knowledge and information varies considerably from weapon system to weapon system, although the necessary types of engineering decisions are very similar. Consequently, engineering decision and design rules vary widely. An engineering decision aid, possibly in the form of an "expert system", is needed to accumulate reliability engineering lessons learned from various weapon systems, perform reliability analysis on available data which may be incomplete, track the weapons system project status, and provide a total reliability environment model.

PHASE I: The initial phase of this SBIR is to evaluate a broad range of reliability knowledge, information, and data to determine the feasibility of developing a total reliability environment engineering decision making aid. This will include (but not be limited to) weapon system life cycle models, reliability block diagrams, reliability prediction models, reliability design allocation techniques, parametric and non-parametric statistical analysis techniques, reliability program tasks, reliability and maintainability demonstrations, reliability acceptance testing, fault tree analysis (FTA), failure modes, effects and criticality analysis (FMECA), reliability scoring conferences, failure reporting, analysis, and corrective action systems (FRACAS), and various reliability-related probability density functions, cumulative probability distribution functions, and hazard functions. Because of the large amount of potential information sources, Phase I will include screening these sources and identifying the critical information necessary for the model. An initial RAPTRE model will be developed during this phase. This model will be used to support a limited number of specific engineering decisions (to be determined by the SBIR team.) For example: what is the "best" allocation of a fixed amount reliability test resources (money and time), given the total reliability environment to date? The RAPTRE must also support Materiel Release reliability decisions as part of Phase I. RAPTRE must provide a comprehensive graphical user interface.

PHASE II: A complete RAPTRE prototype will be developed during Phase II and validated using information from an actual weapon system project. The complete RAPTRE prototype will include a larger set of supported decisions (to be selected by the SBIR team.) In addition, the complete RAPTRE prototype will autonomously (while the model is running) notify the user of

potential reliability issues and provide recommended courses of action. For example: RAPTRE will autonomously analyze trends in component reliability degradation, notify the user, and recommend a course of action such as increased testing or redesign the component. RAPTRE will provide a graphical user interface and network accessible data storage. A goal for RAPTRE is to provide automatic links to relevant data such as RAM prediction component libraries and weapon system component test results.

PHASE III: RAPTRE will be capable of performing reliability analysis and project tracking for any complex system. RAPTRE can be applied to complex equipment, vehicles, aircraft, and spacecraft.

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3) Dennis M. Buede, The Engineering Design of Systems: Models and Methods, VA: George Mason University, 1999

KEYWORDS:
Reliability Analysis, Project Tracking, Decision Making Tools

A01-165 TITLE: Common High Resolution Modularized Millimeter Wave (MMW) Scene Generator

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Tactical Missile

OBJECTIVE: The objective of this topic is the development and application of a modularized millimeter wave (MMW) target and background high resolution scene generator whose underlying algorithms are applicable to both digital and real-time hardware-in-the-loop (HWIL) simulations. The scene generator must be configurable for a variety of MMW and multi-mode sensors employing state of the art signal processing techniques. The technology is applicable to both military and commercial sensor development and testing. Potential commercial applications include simulations for development and testing of millimeter wave communications and imaging systems.

DESCRIPTION: At present, digital simulations for MMW and multi-mode sensor development and testing are custom-designed by the seeker vendor and are verified, validated, and operated by both the vendor and government in simulation-based acquisition. A typical competition may involve several vendors, each requiring high resolution target and background models for proper exercise of seeker algorithms. In the interest of competition fairness, there is a need to assure commonality in these models, which are generally supplied by the government. There is also the need and desire by both the government and sensor vendors to eliminate costly re-design and re-development of digital simulations. Additional efficiencies are realized by assuring commonality between digital and HWIL simulation MMW scene generators.

The MMW scene generator must be capable of integeration with both digital and HWIL MMW and multi-mode seeker simulations. The generator must present a scene having resolution sufficient to current and future seeker signal processing technologies, including synthetic aperture radar (SAR), Doppler beam sharpening (DBS), and high range resolution techniques. The MMW scene generator must be capable of supporting detection, acquisition and tracking modes of the sensor under test. Algorithms employed in the scene generator must be optimized and configurable to support real-time MMW scene generation in a HWIL simulation environment.

PHASE I: Study existing common simulation environments, including digital and HWIL simulations, and current state of the art seeker designs, for input, output, and computational requirements. Design a specification for MMW scene generator which will allow integration of the scene generator into these simulation environments. Develop a software and hardware specification for a MMW scene generator meeting the requirements of the description above.

PHASE II: Implement the MMW scene generator based on software and hardware specifications determined in Phase I. Perform verification of the MMW scene generator for a specific seeker. Demonstrate usability of the MMW scene generator for seeker selection in a simulation based acquisition environment.

PHASE III: Commercial applications for this technology might be found in virtual prototyping of millimeter wave and multimode sensors for communications and imaging systems development. The scene generator developed under this topic would provide an excellent simulation environment to support the conceptual design and testing of single mode and multi-mode millimeter wave systems used in communications and imaging applications.

REFERENCES:
1) Technologies for Synthetic Environments: Hardware-in-the-loop Testing, Proc. SPIE, Vol. 2741, April 1996.
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KEYWORDS:
Seeker, millimeter wave (MMW), hardware in the loop (HWIL), simulations, multi-mode, target, clutter, background

A01-166 TITLE: Embedded Sensor Technology for Solid Rocket Motor Health Monitoring

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PEO, Tactical Missile - BAT Program Office

OBJECTIVE: Establish a means, through non-intrusive embedded sensor technology, to monitor health of solid rocket motors.

DESCRIPTION: The most age sensitive component in a tactical missile generally is the solid rocket motor. MicroElectroMechanical (MEMS) or fiber optic sensors offer means to establish embedded measurement capability for evaluation of motor structural and ballistic integrity. These measurements would supplement environmental data already obtained by a system such as the Remote Readiness Asset Prognostics/Diagnostics System (RRAPDS) and improve logistical readiness. Non-intrusive sensors are desired which must be miniaturized, accurate, sensitive, reliable, possess versatility for measurement of chemical or physical parameters and robustness for installation, be temperature and pressure compensated, have low power requirements, and exhibit long-term measurement stability.

PHASE I: Perform literature review, development, and investigation to select one or two most promising sensor technologies to be used as an embedded sensor for monitoring stress/strain in solid rocket motor bondlines. Establish temperature and pressure sensitivity, long-term measurement stability and chemical compatibility, and sensor calibration procedures. Develop associated prognostics (i.e. what does the sensor reading mean w/r/t solid rocket motor structural and ballistic integrity). Establish integration into RRAPDS system (provide capability for continual or intermittent monitoring of sensor readings through RRAPDS or a data acquisition scheme compatible with RRAPDS).

PHASE II: Installation procedures would be developed and demonstrated on propellant/liner/insulation bondline witness panels. Laboratory analog articles would be fabricated from witness panels for rigorous isothermal combined loads and cyclic mechanical testing, during which sensor readings would be monitored. Known and strictly controlled boundary conditions on the test articles would provide means to analyze and validate sensor readings, and to further develop prognostics for application in full scale motors.

PHASE III: A selected number and distribution of sensors would be employed in a full scale motor casting, to be fitted with a RRAPDS prototype data acquisition system and placed into field deployment at an established Stockpile Reliability Program (SRP) site. Storage of the asset would simulate transient thermal cyclic loads experienced by typical tactical rounds, and would provide a means to validate sensor performance, installation scheme optimization, and assess motor health within normal testing phases of the SRP.

Both MEMs or fiber optic sensor technologies have applications to commercial and military structures, vehicles, pipelines, or DOE reactor vessels. Any bonded interface in a building, a bridge, a road, an aircraft, or an automobile (particularly those composed of polymeric materials which are employed as shock isolators and are subject to severe environmental exposure) may benefit from development of this technology. Structural elements such as annular piping, generator mounts, or aircraft composite wing struts, which are fatigue critical but may not be readily inspectable, will potentially benefit from non-intrusive embedded monitoring devices. Engineers responsible for structural integrity assessment will be provided exact data on loading cycle numbers and magnitudes, rather than having to assert such from empirical models or time under assumed load. Such technology might also provide technical data for evaluation of civilian and military structures subject to hurricane or earthquake scenarios.

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Buswell, J., et al.; "Characterization and Use of Bond Stress Sensors in a Tactical Rocket Motor", American Institute of Aeronautics and Astronautics, AIAA paper #2000-3139, 36th annual AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Huntsville, Al., 16-19 July 2000.

KEYWORDS: Solid Rocket Motor (SRM), Health Monitoring, MicroElectroMechanical (MEMS) Sensors.

A01-167 TITLE: Assessing the Impact of Lead-free Solders on the Long-term Reliability of Weapon System Electronics.

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: National Missle Defense JPO (Joint Project Office)

OBJECTIVE: The objective of this SBIR request is to determine any effects lead free solder may have in a long term storage environment. This research will be used to assess the effects of lead free solder on long-term reliability of systems.

DESCRIPTION: The potential hazards of ground water contamination by lead deposits from solder in discarded circuit boards and associated hardware has prompted governments and commercial industries in Europe and Asia to begin efforts towards replacing lead bearing solders in electronic products. These efforts abroad have prompted the commercial electronics industry in the United States to likewise consider the implementation of lead free solders in their products. As military procurement turns away from captive manufacturers and moves towards commercial off-the-shelf suppliers, the impact had by lead free solder technology on military electronics equipment must be examined. Since the long-term functionality of solder interconnects is critical to the reliability of weapon systems, it will be necessary for the military community to perform studies that will benchmark the reliability of lead free solder joints for future weapon electronics hardware and the anticipated service environments.

A particular concern in the reliability of solder interconnects is their susceptibility to thermal mechanical fatigue (TMF) damage. TMF of a solder joint occurs when the service environment includes cyclic temperature variations. The temperature fluctuations cause deformation to occur in the solder due to the differences in thermal expansion (coefficient) between the circuit board and the component package. The combination of elevated temperatures as well as the deformation caused by temperature cycling can lead to fracture and thus, a loss of electrical function.

PHASE I: The first phase of this project would be investigating and cataloging the different types of lead free solder existing that would most likely be used in commercial and military applications and the different geometries of the solder joints. For this study chip scale packaging and surface mount geometries will be the focus. The focus of Phase I will be to outline a failure model to predict Thermo Mechanical Failure (TMF) of the lead-free solder joints given the specified geometry and environment. Also an environmental stress test would be designed to validate the model in Phase II. The environmental stress screening shall be guided by but not limited to MIL-STD 2164 (Environmental Stress Screening for Electrical Equipment).

PHASE II: Phase II would consist of prototyping and demonstrating the lead-free failure model and validating its results through environmental testing specified in Phase I.

PHASE III: The results of this research would provide documented evidence of the integrity of lead free solder in long-term storage environments. This information would be useful in preparing stockpile reliability assessments of lead free systems and determining periods between rework for extended shelf life items.

REFERENCES:
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2) Jorgensen, IPC, "Lead-Free Electronics: Full Steam Ahead SMT," May 2000
3) Jorgensen, IPC, "Regular or Unleaded? That is the Question... Circuits Assembly," April 2000

4) Handwerker, NIST, "Article Compilation for CircuiTree Lead Free Special Issue CircuiTree," September 1999
5) Jorgensen, IPC Grusd, Agilent David Bergman, IPC Wacko, "Inevitable, Irrelevant, - Oh My! Circuits" Assembly, August 1999

These sources were found on this website: http://www.leadfree.org/

KEYWORDS: Lead-free solder, Long Term Reliability, Thermal Mechanical Fautigue (TMF), Accelerated Life Test

A01-168 TITLE: Development of an Imaging Technique to Identify Angiogenesis

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop, design, and construct innovative screening modalities appropriate to the identification of new blood vessel formation.

DESCRIPTION: The development of improved screening modalities is needed to identify neoangiogenesis. The formation of new blood vessels is a critical component in the healing of many injuries, including surgical wounds, ulcers, non-union fractures (1, 2, 3), as well as the progression of diseases such as cancer (4). In addition, neoangeogenesis can be affected by common therapies, such as nonsteroidal anti-inflammatory drugs (5), and common personal behaviors, such as smoking (6). The ability to determine early in the course of an injury that there is an abnormally low rate of neovascularization could result in early intervention with standard treatments such as surgical intervention or antibiotic treatment. This technology could also identify patients who could be the best candidates for treatment with emerging angiogenic drugs, such as fibroblast growth factor (7) and platelet-derived growth factor (8). Additionally, evidence of on-going or apparently adequate angiogenesis may help soldiers avoid unnecessary additional tests or surgical interventions. More effective determination of neovascularization could reduce the morbidity of injuries, and potentially reduce mortality resulting from complications. In this fashion, soldiers may be returned to full duty more quickly, and with a shorter course of rehabilitation.

The goal of this solicitation is to develop the methodology to identify new vessel formation and confirm the validity of the technique(s). This could be accomplished by a number of complementary approaches involving imaging technology, improved contrast media or data reduction. Imaging technologies could include: (a) magnetic resonance angiography and/or perfusion (8); (b) doppler ultrasound angiography (9); or (c) CT angiography. Improved contrast media could be developed, increasing the sensitivity and resolution of current methods. Enhanced data reduction and analysis algorithms could be added to these other technologies to further accomplish this goal of improved detection of neoangiogenisis. Validity could be confirmed using phantoms that mimic human physiology and/or animal models of wound healing.

PHASE I: The objective of Phase I is to develop the screening modality to identify neoangiogenesis. At this stage the methodology or technology should be able to identify a target of newly developed blood vessels, and a potential assay protocol be described.

PHASE II: The objective of Phase II is to evaluate the safety of the technology in patients. In addition, research in this phase should further develop the methodology of angiogenesis detection as a tool for diagnosing and monitoring the severity and progression of injury or disease.

PHASE III: The development of a screening technique to identify neoangiogenesis would provide commercial potential in several clinical settings. The detection of angiogenesis, or alternatively, loss of blood flow, could have an impact on the treatment of many diseases, including cancer, heart disease and stroke. This phase would involve clinical trials of the screening modality for Food and Drug Administration review of safety and efficacy. The complementary military application of this technology would include the ability to more efficiently detect and treat devitalized tissue associated with projectile injuries, crush injuries, blast injuries, and envenomization events from snakes and spiders. The utilization of this technology in military operational settings could contribute to more effective surgical intervention, reduce the numbers of surgeries required for wound debridement, and reduce morbidity and mortality

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KEYWORDS: Angiogenesis, wound healing, neovascularization,

A01-169 TITLE: A 3-D Volumetric Floating Image with Haptics

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: To demonstrate a PC-based, general purpose surgical simulation workstation training device that allows a human being to experience a realistic "look and feel" while interacting with a 3-D volumetric floating image and co-aligned force feedback to enable a highly realistic surgical simulation.

DESCRIPTION: The workstation must provide realistic, simulated representations of medical procedures. The system should provide glasses-free, full color, full parallax 3-D images that are projected into free space to provide access for force feedback interfaces. The 3-D images should have all of the characteristics of real 3D objects. The tactile object of the force feedback interface should be accurately co-aligned with the 3D visual image to provide a very realistic surgical training environment. The system should provide enough field of view for both the user and an intructor to see the image and the display mechanism must provide an image such that the spatial location of image features in independent of viewing direction.

PHASE I: Develop a realistic prototype of a medical / surgical modeling and simulation device to provide initial and sustainment training for military medical personnel in combat casualty care skills. Address a volumetric 3-D floating image display with a single co-aligned haptics force feedback interface with minimal specifications as follows.

Technical performance parameters and/or objectives are:
* Display resolution - Minimum total resolution of 5,000,000 voxels and minimum transverse resolution equivalent to VGA mode, i.e., 640 x 480.
* Display color depth - Minimum 16 bits of color is requirement; 24 bits is preferred.
* Display update rate - Should be in real-time rate in excess of 20-25 frames / second.
* Display frame rate - Should be "flicker-free", in excess of 40 hz. Minimum update rate of 20 hz or better.

Force-feedback interface update rate - Force feedback update rate should exceed 1,000/hz to provide "real-time" force feedback, that is, to read encoders to determine position, perform contact detection, and output forces to the interface.

PHASE II: Demonstrate a functional prototype of a full performance surgical simulation workstation. Provide a software Application Programming Interface (API) that will enable the development of individual simulation applications. This prototype should include at least the capability to simulate one organ, limb, or whole trauma body as a surgical simulation.

PHASE III: This general purpose platform is applicable to arbitrary military and civilian tactile task training. Additionally the workstation will be a powerful control station for telepresence battlefield surgical applications and telepresence robotic applications in remote exploration of underwater, outerspace, and dangerous radioactive, biological or chemical environments.

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NOTE: First reference is the hallmark textbook about Virtual [Simulated] Surgery, edited by Dr. Richard M. Satava, M.D.
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3) Chapter IV (section F), Joint Warfighting Science and Technology Plan (1997)

KEY WORDS: Modeling and simulation, medical skills training, individual and unit training, medical force readiness, mission rehearsal, 3D display, force feedback, tactile training.

A01-170 TITLE: Preparation and Testing of Human Compatible Serum Butyrylcholinesterase

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: The objective is to develop and produce highly purified human serum butyrylcholinesterase (Hu BChE) for use as a pharmaceutical and bioscavenger to afford protection against nerve agent and pesticide poisoning. In addition, the same enzyme preparation may be used to alleviate succinylcholine-induced apnea and to treat cocaine overdosed individuals. Hu BChE will be prepared for filing for an investigation new drug (IND) application and for clinical trials.

DESCRIPTION: BChE from human plasma is a drug candidate for detoxification of certain harmful chemicals to warfighters, including organophosphorus (OP) chemical warfare agents that contain carboxylic or phosphoric acid ester bonds (1-4). Large quantities of Hu BChE displaying a high stability upon long-term storage are required for defining its therapeutic capacity in vivo, its pharmaceutical properties, and for clinical trials. Several reported procedures (5,6) enabled the purification of the enzyme from pools of animal and human plasma. These techniques, produced cholinesterases (ChEs) from natural sources, which maintained a long residence time in the circulation of animals (7,8). Outdated and otherwise unused human plasma and other blood by-products such as Cohn Fraction IV-4 (depleted of other blood products but not Hu BChE) might be a ready and large source of Hu BChE. In addition, it has been recently reported that through a combination of biochemical and genetic manipulations, a recombinant Hu BChE enzyme product with pharmacodynamic profiles comparable to the native enzyme could be prepared (9). Thus, Hu BChE could be prepared by a variety of methods. e.g., from a supply of outdated human blood products, but the procedure must be ultimately scalable to generate large quantitites of GMP enzyme for the projects below. The resulting purified or recombinant Hu BChE must display the same enzyme activity, resident retention time in circulation, and lack of immunogenicity, as the native human product.

PHASE I: Phase I research will be restricted to showing feasibility of producing, purifying, and/or generating Hu BChE, yielding a product adhering to good manufacturing processes (GMP). In addition, procedures should incorporate the requirement that, in Phase II, it is necessary to demonstrate the chemical and functional equivalence of the Hu BChE product (isolated from plasma or recombinant) with plasma-derived Hu BChE with respect to circulatory stability, immunological properties, and long-term stability.

PHASE II: Define and develop a large-scale process for the preparation of Hu BChE using GMP procedures (and all documentation necessary for FDA approval) according to FDA guidelines for parenteral injection. Ultimately, the goal is to develop a process that could be scalable to handle large quantities of outdated blood; for example, 1-7 tons of Cohn Fraction IV. The generation of Hu BChE will entail defining optimal storage conditions for the product as well as packaging the enzyme product for delivery. Demonstrate stability of Hu BChE through long-term storage studies in vitro. Perform or participate, by providing GMP enzyme, in pre-clinical testing of the Hu BChE by determining circulatory half-life in vivo. Participation in the dual civilian use (e.g., as a cocaine detoxifying agent as described in dual use applications or in the treatment of succinylcholine-induced apnea /pesticide overdose) would provide additional clinical testing.

PHASE III: Produce (large-scale up of GMP Hu BChE production) and support Hu BChE during its introduction into use as a bioscavenger in the military and as a treatment for cocaine intoxication, succinylcholine-induced apnea, and pesticide overdose, for civilian use.

DUAL USE APPLICATION: (A) Hu BChE will provide an immediate pretreatment agent for soldiers who are entering an area where OP nerve agents might be used for an extended period with no weight penalties, behavioral alterations, or performance reductions (1-4,10). The dose administered would determine the level of protection, but at the very least, a dose to protect against 2 LD50 of OP nerve agents could be injected. (B) The same process and advantages would exist for any first responders (civilians) reacting to terrorist nerve gas release/attack or pesticide overexposure or succinylcholine-induced apnea (11). Injection of the bioscavenger enzyme would occur on the way to the incident and provide immediate protection without delay. (C) Hu BChE will also provide treatment for cocaine overdose since the enzyme rapidly hydrolyzes certain non-choline esters including this drug of abuse (12-14). In the United States alone, approximately 165,000 cocaine intoxicated individuals per year visit the emergency room (15). Exogenously enhanced plasma ChE activity was protective against cocaine toxicity in animals. Also, BChE activity is present in the human placenta (16), and alterations in its level may explain why only a few cocaine-exposed fetuses suffer cocaine-related complications when most do not. (D) In addition, Hu BChE could also be incorporated into a product (17), composed of ChEs, oxime, and polyurethane foam combinations, for the decontamination of OP compounds from sensitive biological surfaces such as skin. BChE has already been successfully immobilized by covalently linking the enzymes to polyurethane prepolymers. The sponges should be suitable for a variety of external detoxification and decontamination schemes for both chemical weapons and pesticides directed against ChEs in the military field environment and the civilian sector at large events, subways, and prevent secondary contamination of first responders and hospital personnel. (E) Hu BChE could be incorporated into a product for biosensing OPs. The use of ChE biosensor devices in the field for the detection of OP compounds, has been demonstrated (18). The immobilized BChE enzyme sensors have the unique ability, unlike the current OP indicating ticket, to detect OPs in any environmental condition, such as vapor, water, or even soil, and in circumstances requiring long-term remote sensing. In addition, use of Hu BChE would provide these detection sensors with the same sensitivity to OPs as human beings, unlike the current sensing ticket that relies on an eel ChE.

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KEYWORDS: bioscavengers, human, butyrylcholinesterase, parenteral injection, stabilization, organophosphorus chemical warfare agents, pesticides, cocaine, succinylcholine apnea, biosensors, decontamination

A01-171 TITLE: Development of a Mobile, Miniaturized, Field Deployable Pupillometer to Assess Fitness for Duty

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PM, Military Operational Medicine

OBJECTIVE: Develop a small, light-weight, self-contained pupillometer capable of measuring saccadic velocity, initial pupil diameter, amplitude of pupil constriction, and latency of pupil constriction for primary use by operationally deployed military forces. Purpose: These objective parameters may be obtained in 10 seconds with a pupillometer device and have been shown to correlate with cognitive fittness.

DESCRIPTION: Require a pupillometer no more than 15 pounds and 1960 cubic inches with integrated computer control and data storage capability. Pupillometry system requirements are resolution of saccadic eye movements to .1mm with a sample rate of 500 Hz and pupil amplitude changes of .05mm with sample rate of 60 Hz. Compatibility with external 120V power sources required. Pupillometer needs to sample eye parameters for no more than 30 seconds and provide message to user immediately upon completion of test as to relative fitness for duty as compared to prior determined baseline. Potential problems requiring inovative solutions include methods to maximizing pupil capture in varying ambient light and sleep deprivation conditions. Capture of pupil must exceed 90% at second attempt.

PHASE I: Submit design for pupillometer meeting above requirements. Design and execute study to determine effect of ambient light differences on Saccadic Velocity, Pupil Amplitude, Constriction Latency, and Constriction Amplitude.

PHASE II: Determine requirements and institute them for measuring and compensating for light and dark adaptation caused by changes in ambient light across bright day to dark night spectrum. Develop test prototype.

PHASE III: The resulting pupillometer will be able to provide fitness for duty assessments based upon neurophysiological measurements for both soldiers and civilian shift or extended duty workers. Additional applications in the medical community could include evaluation at bedside or in clinic of neurophysiological status of medically or neurologically impaired patients.

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KEYWORDS: pupillometer, fitness-for-duty, neurophysiology, saccadic velocity

A01-172 TITLE: Blood Collection and Separation Device

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: The objective of this topic is to develop a new automated medical device to replace current manual methods and bag sets used for separation of whole blood into plasma and red blood cells. The device is required to be lightweight (less than 50 pounds) and compact (less than 1 cubic foot), with a needle for venipuncture into the blood donor's arm.

DESCRIPTION: While blood is being collected, the system is required to automatically anticoagulate, separate the whole blood into plasma and red blood cells, leuko-reduce & add a storage solution to the red blood cells. The goal of automation is to eliminate the need for operator intervention after needle insertion until the blood processing is complete. The time from start of setup to end of teardown must be less than 15 minutes.

Other goals are to: provide the means for the operator to pre-select the volume of the collection; develop a convenient cassette assembly of the disposable components with bags preattached; concentrate hematocrit to 70% or more; provide data acquisition capability to verify and validate the process; prepare submittal for FDA approval for the device. Candidates must have experience with blood technology, engineering design of medical devices, and the FDA approval process.

PHASE I: Investigate engineering feasibility of the device. Conduct laboratory experiments to validate design concepts. Design and fabricate a laboratory prototype.

PHASE II: Develop the laboratory prototype into a working model. Refine the design; conduct appropriate testing in preparation for submittal to the FDA for approval.

PHASE III: Obtain FDA approval and mass-produce the blood separation device for both the military and commercial markets. The military has an established blood donation program that is independent of civilian donation drives. The Army and all other armed services will utilize this device for all military blood donations because it will reduce costs and manpower requirements. It will also improve quality control due to automation. This blood separation device will also be utilized by the Red Cross and other non-military blood banks in civilian blood donation drives for the same reasons (reduced costs & improved quality control).

DUAL -USE APPLICATION: This device will have widespread application in the commercial market where 12 million units of blood are collected annually in the U.S. at a cost of $125 per blood unit. Therefore, the 15% cost savings would amount to $225 million per year. The device would likely be utilized worldwide which would further increase the savings dramatically.

OPERATING AND SUPPORT COST REDUCTION (OSCR): The device is expected to reduce processing costs by 15%. The military typically collects 100,000 blood units/year at a cost of $90 each. Therefore, the annual military savings are $1.4M.

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KEYWORDS: blood, blood separation, whole blood, blood processing, fresh Blood, blood separation

A01-173 TITLE: Development of Web-driven Bioinformatic Platform for Microarrays

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PM-Military Infectious Diseases Research Program

OBJECTIVE: The overall goal of this SBIR topic is to support efforts in the Objective Force Technology Area: Medical. We seek to capitalize upon recent advances in enabling technologies in both de novo and Affymetrix microarrays. Specifically, we seek the development of an innovative, fully-functional, locally-controlled, web-enabled product for research input and output data associated with de novo and Affymetrix microarrays processes. Innovative enhancements of informatic tools for microarray technology supports DoD's Defense Technology Area Plan in Infectious Diseases of Military Importance, more specifically, STOs III.ME.1996.01 Multi-Stage, Multi-Antigen Plasmodium falciparum Malarial Vaccine; III.ME.1996.02 Drug to Treat Multi-Drug Resistant and Severe and Complicated Malaria; III.ME.2000 a Multi-Antigen Multi-Stage Plasmodium vivax Malaria Vaccine.

Specifically, we seek development of an innovative, highly flexible relational product and interface package that will replace or significantly improve existing models [GeneX by NCGR (National Center for Genomic Research), AMAD by microarrays.org, ArrayDB by NHGRI (National Human Genome Research Institute)] while remaining compatible with existing formats and technologies. The product will provide storage for all de novo and/or Affymetrix microarray related data including output from 5 basic research and clinical sites, and be capable of expansion across multiple sites. Initially, the product must serve multiple users at 5 sites, with fewer than 10 persons accessing simultaneously, yet include provision for scalability to 250 persons with up to 25 simultaneous logins. The product must be gigabyte in size, though it is expected that a substantial portion (<40%) will be used for the storage of uncompressed tiff images and compressed jpeg's. Product design must be sufficiently flexible to incorporate HTML, XML, novel web-related protocols, new analysis software packages as well as scientific and computer innovations as they develop. The product must be able to interface and/or recognize output of existing analysis packages to include, but not limited to, GenePix, Partek Pro, Genespring and ImaGene, and must contain hypertext links to existing databases including, but not limited to, dbEST, Entrez, GeneCards, KEGG and UniGene. An innovative platform independent package is required for data presentation and updates. This product can be a stand-alone program, an add-in for a web browser, or simply integrated with web browser, but must automate data uploading. Data flow must be optimized and validated at each point with the ability to recognize the source, type and location of the data and update the database appropriately.

PHASE I: Evaluate and demonstrate utility of selected approach for meeting product development. Exit criteria include provision of an alpha product with at least 30% of desired features.

PHASE II: Complete development of beta version of product with at least 95% of desired features. Demonstration of the beta version of the prototype with at least 95% desired features will result in the termination of Phase II.

PHASE III: The development of a common platform for robust, efficient, convenient, highly flexible management and analysis of microarray data for DOD drug development/discovery and vaccinology programs would be expected to be readily exploited by researchers in other disciplines. A platform that allows researchers to conduct analyses across hundreds or thousands of

experiments would dramatically enhance our capacity to identify "fingerprints" or signatures of gene expression. Such a platform would be expected advance efforts in vaccine discovery, drug development and discovery, toxicology, and diagnosis and monitoring of infectious diseases of military and civilian import (HIV-1, malaria, pathogenic bacteria, and viruses).

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KEYWORDS: microarrays, informatics, database

BACKGROUND:

A critical component of the genomics revolution is the transformation of enormous amounts of biological information into a relevant and easily manipulated electronic format that readily leads to rapid information-based approaches to biological problems. While whole genome or gene-expression microarray-based studies encompassing tens of thousands of genes readily complement gene-sequence based approaches, little attention has been paid to the computational biology underlying integrated data management and analysis. Currently, these technologies have outpaced the scientific community's ability to manage and extract biologically meaningful information. Development of a robust, innovative, flexible, fully-integrated and functional relational web-enabled system for manipulation of microarray data is imperative since no commercial product currently exists.

A01-174 TITLE: Development of Cellular Profiles using Microarrays and Nanosensors for the Detection of Cancer

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop, design, and construct innovative screening modalities and associated materials to detect and diagnose precancerous and cancerous lesions using cells isolated from blood, other body fluids, or tissue.

DESCRIPTION: Building unique profiles of gene expression and/or the chemical environment within cells would be a valuable tool in guiding the diagnosis of, and tailoring treatment for individual patients. As such, the development of better modalities to detect and diagnose precancerous conditions and cancerous lesions are needed. Better tests could be developed to assess and characterize the clonogenic potential of cancer cells within the patient, thus providing the ability to intervene earlier in cancer progression and metastases. For example, the intracellular chemical profile of free radical and other oxidizing compounds within the tumor could provide diagnostic information. In addition, cellular genetic profiles could be established to reflect the expression of a (sub)set of genes expressed either at the beginning of therapy, or after a course of treatment. Microarrays may be used for the establishment of such genetic profiles of a tumor, guiding the choices of therapy offered to the patient (1). These goals could be facilitated or expedited by the development of better materials for the construction of microarrays (2). New technologies such as fiberoptic nanosensors could also be developed to measure the intracellular chemical environment of tumor cells, and assess or evaluate the patient's response to therapy (3). The overall goal of this solicitation is to develop standardized tests that can act as reliable predictors and indicators of cancer development, effectiveness of treatment, and/or recurrence.

PHASE I: The objective of Phase I is to identify and outline the feasibility and applicability of the methodologies proposed for use in determining a cellular profile. A successful cellular profile should clearly differentiate or distinguish normal from disease using stored tissue, fresh tissue or tissue culture.

PHASE II: The objective of Phase II is to test the potential of the techniques in determining specific cellular profiles from patients with cancer. In this phase, a defined testing protocol should be developed. The overall goal of a new test utilizing microarrays or nanosensors is the develop tests to detect neoplastic cells with at sensitivity of greater than 95% and specificity greater than 95%.

PHASE III: The development of very sensitive and highly specific assays that would accurately detect and diagnose cancer. The technologies developed for this topic have wide applicability to militarily relevant topics, including force protection (microarray technology) and sensors and information processing (personal sensors for detection of chemical agents). This phase would involve clinical trials of the screening modality for Food and Drug Administration marketability. Early diagnosis of breast, prostate, and ovarian cancer is needed to best care for military personnel and DOD beneficiaries and to reduce the health costs incurred in caring for these individuals.

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KEYWORDS: microarray, nanosensors, Cancer detection, Biotechnology

A01-175 TITLE: Ruggedized Medic

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: Provide a prototype ruggedized medic's Personal Digital Assistant (PDA) personal computer (PC) for user testing in Advanced Warfighter Exercises (AWE), Joint Technology Demonstrations (JTD), Advanced Concept Technology Demonstrations (ACTD) or Army Concept Evaluation Programs (CEP) which are intended to evaluate emerging first respondermedic telemedicine and medical informatics decision support systems, such as the medical record "dog-tag" like Personal Information Carrier (PIC), the Field Deployable [medical] Record (FDR), and the Special Operations Forces Medical Handbook (SOFMH). Field evaluations of the PIC and FDR in the September 2000, Joint Combined Forces AWE were hampered by numerous failures of Commercial off-the-shelf Technology (COTS) notebook and laptop computers, which were not sufficiently ruggedized for field use. As a result the critiques from these evaluations have focused on the computer hardware rather than on the medical application software projects, which were the subjects of the evaluations. Likewise, the Army Medical Department Center and School Directorate of Combat Developments (AMEDD TRADOC Combat Developer) has criticized the SOFMH project for developing software media (CDROM) that targets standard COTS PC hardware, which is not sufficiently ruggedized for special operations forces (SOF) operations, and is too large for special operations missions. The mission of developing and fielding ruggedized computer hardware for AMEDD medics belongs to the Program Manager for Medical Communications for Combat Casualty Care (PM MC4). PM MC4 has not yet fielded a ruggedized medic's computer that meets the technical requirements of the PIC, FDR and SOFMH. Other field medical informatics application developers also need a ruggedized computer for testing their applications.

DESCRIPTION: The Army Medical Department needs a small ruggedized personal digital assistant (PDA) personal computer (PC) for use in combat casualty care and field health services support operations. This device must meet the requirements of existing and emerging medical software applications for field medical first responder use. Ideally this device would support both the Palm computer operating system (PALM OS) and the Windows CE and/or Windows NT operating systems. Since pocket sized PCs already exist for the PALM and Windows CE operation systems individually, it is theoretically possible to combine the chips of these existing PCs into a single PC that supports both operating systems, and is also ruggedized. The military medical community intends to use both government developed and commercially developed medical application software on the medic's PDA. This approach would avoid significant development costs to the military in the acquisition of routine medical software and maintenance, and would allow our active and reserve Army medics and physicians to use the same software programs for patient care applications within the military, with which they are familiar from academic training and civilian practice. Much of the most popular and usuable physicians' medical software applications for pocket PC applications are written for the PALM OS; however applications that require color graphics or data intensive images, like radiology, often require Windows CE or Windows NT pocket PCs (Color PALMs that support motion video are available in Japan and are coming on US market soon). Windows CE or Windows NT applications support PCMCIA ports (required for medical PIC) are more easily upward scalable for use on lap top and desktop PCs at larger field or fixed medical facilities. A single Medic's PDA tool that supports both operating systems and is sufficiently rugged for field applications would support multiple medic and physician computer requirements in both the military and civilian communities.

PHASE I: Demonstrate a ruggedized prototype version of a Department of Defense Common Operating Environment (DOD COE) compliant COTS personal digital assistant computer that meets technical requirements of the PIC, FDR, and SOFMH and supports commercial medical software applications that run in either the PALM OS or Windows CE (or Windows NT)..

PHASE II: Field test the ruggedized Medic's PDA in operational environments with conventional and Special Operations medics employing PIC, FDR and SOFMH software systems.

PHASE III: Once the concept and technology are proven in an ATD, ACTD, AWE, or CEP, the ruggedized medic's personal digital assistant computer could be acquired for medical organizations that need it by the Program Manager, Medical Communications for Combat Casualty Care (PM MC4) via the Army Warfighter Rapid Acquisition Program (WRAP) for field use in exercises, actual operational deployments, or both.

DUAL-USE APPLICATIONS: A ruggedized hand-held computer digital assistant for use by military medic first responders in telemedicine and medical informatics decision support and medical record keeping applications will also have wide-spread application for civilian first responder emergency medical treatment (EMT) personnel. In both military and civilian first responder applications, the device must be rugged enough to withstand constant jolts and drops without loss of memory or damage to viewing screens or processors. If proven via military trials to be rugged enough to support field medical operations, this ruggedized medic's personal digital assistant computer could be marketed to civilian makers of mobile emergency medical equipment.

REFERENCES:
References to medical PDA computer applications in the civilian environment are numerous and may be easily accessed via the world-wide Web using eithin MEDLINE, Greatful Doc, or PUBMED tools provided at no cost via the web by the National Library of Medicine. References to military combat casualty training and operational experience with palm based and laptop PCs can be made available on request.

KEYWORDS: ruggedized PC, personal computer, Hand held PC, Notepad PC, Palm PC, Personal Digital Assistant (PDA), Medic's PDA, Warrior Medic, Special Operations Forces Medical Handbook (SOFMH), Special Operations Medical Diagnostic System (SOMDS), Personal Information Carrier (PIC), Field Deployable Record (FDR)

A01-176 TITLE: High-Throughput Screening of Whole Blood Cholinesterase Levels

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: The objective is to advance a differential blood cholinesterase protocol from the research bench top to field hospital and hand-held, field deployable, medical diagnostic units. Unlike the conventional clinical tests or the Test-Mate OP™ unit, the method should provide a full analysis of the patient's cholinesterase levels, not rely on the addition of selective diagnosing acute (AChE) or chronic (BChE), use a single non-invasive blood collection technique (finger prick), not be labor intensive or otherwise complicated, and produces results in less than six minutes. These systems will provide the army and general public health clinics with units capable of screening and confirming exposure of soldiers/crop dusters/athletes/first responders to chemical warfare agents/pesticides/or other such toxic chemicals. In addition, these systems are critical in the discovery of new therapeutic agents for prophylaxis, neuroprotection, and treatment of chemical warfare agent poisoning.

The successful implementation of this technology will result in a high rate of return on two levels. First, the defense establishment will be provided with a much-needed portable diag-nostic unit capable of performing clinical blood analysis including cholinesterase profiling in the field. Second, the civilian market will be provided an invaluable tool capable of diagnosing acute (AChE) and chronic (BChE) exposure to neurotoxic agents including pesticides, anesthetics, narcotics (eg. cocaine), and chemical warfare agents.

DESCRIPTION: Two separate diagnostic units are proposed. First, a self-contained clinical ro-botic system capable of simultaneously determining the concentrations of human AChE and BChE present in unprocessed whole blood is needed for the mass screening clinical samples. The product should differentiate cholinesterases using differential methodology already developed.1,2 In addition, the technique should (a) be capable of screening 2500 samples per day, (b) provide a precision of less than or equal to 1% and an accuracy of 99%, (c) be environmentally as well as user friendly, (d) possess a large dynamic working range, (e) carry our all data reduction auto-matically, and (f) use a minimal amount blood obtained from a simple and non-invasive process, e.g. a finger prick.

The second unit, a forward-deployable, lightweight, hand-held medical diagnostic aide, based on the same detection scheme used in the clinical system, is required for screening single samples in the field. This unit should be compatible with the i-STATÒ system (cf. www.i-stat.com for complete product specifications) or some other off the shelf commercial hand-held blood chemistry analyzers. In addition, the unit will (a) screen single blood samples in less than two minutes, (b) contain all necessary

reagents and standards, (c) initiate and carry out all neces-sary sample manipulations, reactions, and data processing automatically, (d) be environmentally as well as user friendly, (e) possess a large dynamic working range, (f) obtain a minimal amount blood in a simple, single, and non-invasive process, e.g. a finger prick, and (g) provide the same values as that calculated by the hospital unit. The last item will allow direct and reliable com-parison of field and clinically determined results.

PHASE I: Design, validate, and demonstrate the efficacy and robustness of a semi-automated quantitative system for screening human unprocessed whole blood for AChE and BChE levels. The detection scheme must be easily portable to the fully automated as well as hand-held medi-cal diagnostic aides. Evaluate methodology and techniques for reliably obtaining minimal blood volumes and storing/preserving such blood samples (to mimic time blood would be stored prior to testing). Finally, prototype reaction chambers used in both systems should be designed, con-structed, and evaluated.

PHASE II: Extend the technology developed in Phase I to fully automated self-contained and hand-held systems. It is expected that the robotic system will consist of a small chamber capable of holding 32 individual samples, a linear array of auto-injectors used for sample manipulation/preparation/reaction initiation, and an analytical detection system. The whole system will be capable of maintaining constant temperature regardless of environmental temperature. All samples should be manipulated/started simultaneously and should possess a turn around time of less than five minutes with a target optimum of less than three minutes. The hand-held unit is envisioned to consist of micro-fluidic cartridge and the appropriate software that is easily ported to the i-STAT® plug in or other such commercially used bed side blood chemistry analyzer. The cartridge must contain all of the necessary components required to perform the assay including buffer, standards, substrates, etc. In addition, a sterile single use lancet should be built into the cartridge to facilitate sample collection. Since the WRAIR bench top methodology requires less than 5 μL of blood, we anticipate that less than 10 nL (500-fold less) would be required in the field using advanced micro-invasive technology such as a micro-needle (Kumetrix, Inc – www. kumetrix.com). The sample can be applied to the cartridge either by dropping the blood into the sample chamber or by capillary action if using micro-needle sampling. In addition, all necessary sample dilutions will be carried out automatically by the sample cartridge when inserted into the device. Therefore, no manipulations will be required by the end user. This contrasts with the Test-Mate OP kit, which requires several manipulations. In addition, the Test-Mate OP kit has several separate disposables and biohazards, while our cartridge would be self-contained. Finally, the reliability, detection limits, accuracy, precision, and linearity of both systems must be demonstrated by performing cholinesterase analysis on matched control and test blood samples treated ex-vivo under a variety of conditions.

PHASE III: The public, farmers, crop dusters, and particularly migrant farm workers face health risks associated with organophosphates during the use of commercially available pesticides. More than 23,000 emergency room visits per year in the United States can be accounted for by pesticide poisoning. The method would enable screen-ing of the public for anesthesiology sensitivity (potentially fatal outcome), the result of a mutant BChE occurring in about 10% of the population. The technology developed for screening of or-ganophosphate exposed soldiers would have direct applicability to the screening/conformation of the public exposed to pesticides as described above and the public exposed to nerve agent as in the 1995 Tokyo subway incident. The possibility exists that terrorists may use this type of chemical agent at sporting events or other such gatherings.

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KEY WORDS: Mass screening, automated instrumental analysis, toxic chemical warfare, hu-man acetylcholinesterase, and human butyrylcholinesterase

A01-177 TITLE: Technologies to Reduce Water Requirements of Soldiers in the Field

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Military Operational Medicine, PM

OBJECTIVE: Develop state-of-the-art personal devices to reduce the amount of water soldiers must carry during field training and deployment. In the field, foot soldiers commonly have high rates of energy expenditure, frequently work in hot conditions where sweat rates can be high, are resupplied infrequently, and often carry loads of 100 lbs or more. Water can be 10 to 20% of this burden. Typical field deployments three to five days. The goal of this topic is to identify and develop personal devices to reduce water losses and reclaim water, thereby reducing the amount of water soldiers must carry. Technologies developed must be safe, unobtrusive, non-pharmacologic, low-power, inexpensive, and lightweight.

DESCRIPTION: Technologies are needed to alter the balance between water intake and water loss in favor of the soldier. Although a wide range of methods to reach this goal are possible, successful submissions will focus on one or two devices. The proposed approach should be safe and not interfere with normal physiologic functions such as sweating, heat dissipation/retention, and obligate urinary water loss. Normally, water is gained primarily through pre-formed dietary water in food and drink, although additional water is gained by the combustion of food (metabolic water), and water influx through the skin and lungs. Water losses include obligate urinary water loss, fecal water loss, respiratory water loss, and cutaneous water loss, including sweating. Sweat losses can be substantial during heat stress. Water management strategies might include methods to: recycle urine into potable or non-potable (house keeping) water, limit respiratory water loss in the cycle of inhaled air humidification and exhalation, assess urine composition and provide feedback needed to optimize fluid (water plus electrolyte) consumption patterns, retrieve unevaporated sweat, improve evaporative cooling, and promote convective heat losses during exercise.

PHASE I: Identify devices to reduce the water soldiers need to carry under given environmental, clothing, and work rate conditions. Provide quantitative scientific basis for chosen approach(es) based on an understanding of existing technologies and literature. Criteria: achieve a predicted reduction in water requirements of at least 10%. For example, realize a 400 ml/day savings for a moderately active soldier with 4 liter per day water requirement. Device or technologies should not weigh more than 20% of the weight of the water saved, or about 40 g or ~1.5 oz for the above example.

PHASE II: Develop three or more prototypes of each device that are suitable for testing. Provide bench test data demonstrating device durability and functionality. Coordinate with the U.S. Army Research Institute of Environmental Medicine, Natick, MA, to collect experimental data to confirm functionality. This phase should culminate in a detailed specification and demonstration of prototype system(s) that meet minimum criteria stated above.

PHASE III: This phase focuses on (a) producing water conservation systems to the specification established in Phase II effort, and (b) performing the tests needed for FDA approval. The ultimate goal is to develop effective, easy-to-use technologies and/or interventions that meet the need for water conservation in military and industrial workplaces where water availability is problematic. Specific examples include firefighters and personnel encapsulated in biological/ chemical protective ensembles.

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2) Body Fluid Balance: exercise and sport. Edited by E.R. Buskirk and S.M. Puhl. CRC Press, 1996.
3) Dune by Frank Herbert, (april 1984, reprinted 1999, Mass Market Paperback).

KEYWORDS: dehydration, hypohydration, water requirements, water balance, soldier load, water demand, hydration, water intake, water loss

A01-178 TITLE: Irrigation Debridement Device

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Combat Casualty Care, PM

OBJECTIVE: Development of a wound irrigation device that is lightweight, portable, small, with diminished fluid requirements to cleanse deep wounds in an austere environment.

DESCRIPTION: Debridement along with irrigation is the mainstay of management of any open wound, particularly those associated with fractures. The purpose of this is to remove the devitalized tissue as well as remove contaminants. Inadequate dedridement and irrigation will lead to a deep infection with possible osteomyelitis delaying recovery and compromising outcome of the wounded individual (to include possible need for amputation). Current methods in addition to surgical debridement involve the use pulsatile lavage with or without antibiotics utilizing typically at least nine liters of sterile fluid solution. However, the current concept of utilization of medical resources in the battlefield requires a lightweight, portable and highly mobile unit. This precludes the use of adequate irrigation fluid given today's irrigation systems. Development of a lightweight, portable irrigation system which requires significantly less fluid use and/or allows for recirculation or allows for use of local water supply (in-line sterilization) would allow for adequate debridement and irrigation of the wound in the austere far-forward scenario. The current effort would develop a lightweight, rugged device with low fluid requirements that would be transportable to the far forward area but also be useful in the rear for appropriate wound irrigation.

PHASE I: Product design and development. Evaluate size and weight savings compared to existing systems.

PHASE II: Evaluate wound debridement in established contaminated wound models and asses ease of use.

PHASE III: MILITARY USE: This device could be used at all echelons of care particularly echelon II and higher to debride deep wounds while decreasing the critical supply burden imposed by current methods. POTENTIAL COMMERCIAL MARKET: Such a device could be used in the civilian sector which would reduce the requirements for sterile fluids, decreasing overhead, while allowing for appropriate wound debridement and irrigation.

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KEYWORDS: wound, irrigation, debridement, lavage, open wound, open fracture.

A01-179 TITLE: Development of Two-stage Multivaccine Delivery System with Protective and Bioadhesive Properties for Oral Immunization

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: Design, produce and evaluate in a Phase I study a two-stage carrier system for controlled and pulsed-release delivery of anthrax vaccine via single-dose oral immunization, which would protect against aerosol-delivered high challenge dose of anthrax spores.

DESCRIPTION: Most of the vaccines with military relevance require multiple immunization. Anthrax, botulinum and plague vaccines require 6, 3 and 3 parenteral doses to stimulate full protection, respectively. Parenteral immunization stimulates systemic immunity, without stimulating mucosal immunity, which provides added protection of the alimentary and the respiratory tracts including the lung. Due to the movements of lymphocytes between the mucosal sites, oral immunization with vaccine(s) protects the alimentary and also the respiratory tract including the lung against microbial and toxin challenge which enter the body via these routes. Vaccines against diarrheal diseases are administered orally, but due to the aqueous nature of the vaccine full protecion require multiple doses. The proposed two-stage delivery system would present the aqueous vaccine to the antibody-producing cells in a non-aqueous matrix, and in conjunction with a mucosal adjuvant, full immunity can be attained by a single oral immunization dose. Most of the conventional aqueous and recombinant vaccines require augmentation of their potency, which can efficientley provided by a two-stage delivery system to be developed for that purpose. In addition to the above mentioned advantage, the two-stage vaccine-carrier system for a single-dose oral immunization offers additional advantages: (1) oral vaccine is better tolerated, and it is unlikely to cause side effect; (2) it can be self administered in field conditions without medical personnel; (3) it does not require multiple trips to the medical facility (4) it saves medical supplies and expenses; (5) the lyophilized microencapsulated vaccine has a long-shelf life, and it is more stable at elevated temperature; (6) the two-stage delivery system can be developed to deliver three-four vaccines, thereby it can protect against multiple challenges.

To achieve the objective of a single oral immunization, the selected recombinant protective antigen (PA) of anthrax vaccine is incorporated into a biodegradable primary carrier with controlled and pulsed-release rate property, which will assure two-three antibody peaks equivalent to multiple immunizations. The primary carrier will be enclosed in a biodegradable secondary carrier

capable of protecting the primary carrier/vaccine complex against the low pH of the stomach. Because of its composition, the secondary carrier is designed to desintegrate upon reaching the intestin, and at that time the vaccine-containing primary carrier is released. For maximized increased bioavailability of the vaccine, the primary carrier should display biadhesive properties toward mucosal membranes of the intestin, where the vaccine-containing particles are taken up by the antibody-producing cells.

PHASE I: The Principal Investigator (P.I) should identify and develop the primary and the secondary delivery system for the release of the PA vaccine and evaluate the system in proper animal models.
A. In early part of Phase I study the primary and the secondary carrier should be standardized and evaluated for stimulation of the PA-specific antibody response of the mice using enzyme-linked immunoassay (ELISA), which will enable to select with the concurrence of the Contracting Organization Representative the best methodology and the best delivery system. The selection process relies on the antibody response without challenge study. The polymer used for incorporation of the PA vaccine into the primary carrier should be completely biodegradable and biocompatible for humans. Biopolymer with such properties could be the same or similar to poly-lactide-co-glycolide (PLG) used as carrier of tetanus vaccine which is at the final stages of the development by the World Health Organization. The encapsulation procedure can be an established methods with or without the use of organic solvent, and a novel method developed by the responding organization. With any polymer used, the vaccine released by the polymeric carrier should stimulate three distinct antibody peaks with several weeks between the peaks. To avoid waste of the vaccine, the encapsulation efficacy of the vaccine should be at least 80 %, and the core loading should be at least 4-5 %. To achieve optimal antibody response by a single immunization, the primary carrier should have mucoadhesve properties, and mucosal adjuvant and protein stabilizer (if needed) should be incorporated into the carrier. The release kinetics of the adjuvant should approximate of that of the vaccine. The dose and the use of mucosal adjuvant (heat labile enterotoxin of E. coli, or CpG, a synthetic oligodeoxynucleotide, or interleukin 12), will be provided by the COR. At the conclusion of part A of Phase I study the best incorporation procedure and the best polymer formulation should be selected to perform the efficacy study in part B.

B. In the later part of the Phase I study, the antibody response and the protective efficacy of a single vaccine/adjuvant dose delivered by the best two-stage carrier system selected at the conclusion of the early stage of Phase I study should be evaluated in rabbits. The antibody response and the protection in rabbits should persist for 4 month as detected respectively by ELISA test, and by aerosol-delivered anthrax spore challenge. With the exception of the challenge study of rabbits, the contractor should perform all in vivo animal immunization studies of mice and rabbits, and all the in vitro ELISA tests. Challenge of the rabbits immunized by the contractor will be performed at USAMRIID.

To accomplish the goals of parts A and B of the Phase I study, it will be needed to request the Phase I option, which would extend the contract period for the maximum allowable 10 month. The suggested estimated time periods needed for completion of the extended Phase I study is : standardization of the primary and the secondary delivery system, 0 to 3 month ; demonstration of the biological activity of the vaccine in mice delivered by several formulations and methods of preparation of the two stage delivery system, 3-6 month; and demonstration of the protection stimulated by the selected best formulation of the system , 7-10 month.

PHASE II of the development will entail evaluation of the two-stage delivery system to provide full protection with anthrax PA vaccine for at least 1 year against anthrax spore challenge in small and large laboratory animals. Phase II will also entail the development of a militarily-relevant prototype multivaccine, two-stage carrier system to stimulate full protection in their respective proper animal model for at least one year against aerosol-delivered highest possible respective challenge level. These vaccines will include anthrax PA, plague, Q fever and vaccine against an emerging threat as it will be identified by the contracting organization before strating Phase II studies. If it is deemed necessary, the composition of these vaccines could change.

PHASE III: (1).The completed delivery system can be used for self administration via the oral route of antiviral, antibacterial and antifungal therapeutics and antibiotics. Oral administration of therapeutics and antibiotics by the two-stage delivery system with short-duration release kinetics would be useful for military personnel and for civilian population as well. The carrier system can also be used for the purpose of gene therapy of cancer and AIDS. (2). The completed prototype multivaccine carrier (anthrax PA, plague, Q fever, and an emerging threat vaccines) can be applied for the oral delivery of other militarily relevant vaccines of bacterial (diarrheal diseases, cholera), viral (Filo-, Arena,- Bunya-, and Orthopox viruses), or toxin (botulinum and ricin) origin which are already developed or being developed for the U.S. Armed Forces. The two-stage carrier system can be applied for the delivery of vaccines made by conventional or by recombinant technology for the military, as most of these vaccines require potentiation of their efficacy. Commercially, many of the vaccines with military relevance can be used in the general population as well, to protect against bioterrorism.
Additional commercial application with large market potential is to apply the technology to vaccines used to immunize the general population against polio, influenza, and other viral and bacterial infections.

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individual microspheres and intestinal mucosa.. J. Control. Release. 34:251.
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KEY WORDS: anthrax vaccine, primary mucoadhesive carrier, secondary protective carrier, single oral immunization, pulsed-release of vaccine, mucosal adjuvant, antibody response, protection, aerosol challenge.

A01-180 TITLE: Needle Thoracentesis Simulation Workstation for Medical Training

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: To demonstrate the advanced development of a virtual workbench simulation device for simulating needle thoracentesis for far forward battlefield and civilian pre-hospital emergency management of chest trauma.

DESCRIPTION: A full performance virtual workbench simulator for training the use of needle thoracentesis for emergency treatment of chest trauma by the military in wartime and by civilian health care providers in the private sector.

The following performance objectives should be met:
1. The simulator will provide visual and tactile feedback consistent with the placement of a needle / catheter combination in an adult patient's chest.
2. The simulator will have qualities allowing the user to palpate bony landmarks of the shoulders and chest.
3. The simulator will allow for the use of a variety of needle / catheter sizes and types, and both plastic and glass syringes.
4. In addition to the virtual representation of the thorax, fluoroscopic and 3-D bone views demonstrating real time needle / catheter position should be included.
5. The user interface should have a capacity for altering patient condition, inducing complications and the ability to change the patient's position in space.
6. The user interface should consist of a teaching, rehearsal and testing module that can be followed in real time by an instructor as well as saved for future use.

PHASE I: Develop the concept and design for a prototype of a virtual workbench simulator for training needle thoracentesis for emergency management of chest trauma.

PHASE II: Demonstrate a functional prototype of a full performance virtual workbench simulation device that replicates accurately the training of the use of needle thoracentesis for emergency management of chest trauma. Develop a software Application Programming Interface (API) that will enable the development of individual simulation applications. This prototype should possess at least the capability to simulate needle / catheter insertion in at least a normal adult anterior thorax.

PHASE III: This virtual workbench simulator is applicable to individual military and civilian simulation training in the use of needle thoracentesis for emergency management of chest trauma.

REFERENCES:
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KEYWORDS: Modeling and simulation, medical skills training, individual and unit training, medical force readiness, mission rehearsal, needle thoracentesis, advanced trauma life support.

A01-181 TITLE: Technology to Replace Cloning for Cost Effective and Large Scale Generation of Long Polynucleotides

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop a technology to replace long and tedious procedures of cloning, plasmid production, DNA isolation and purification of large number of genes. We would like to have a simple test-tube DNA/RNA generation system to replace cloning that will provide a continuous supply of DNA standards for a large number of defined genes within a short period and in an efficient and cost-effective manner.

DESCRIPTION: The short term goal is to develop a high risk project to successfully clone DNA in a simple test tube format replacing the traditional cloning methods. There are no alternative procedures available to day to carry out such tasks. The long-term objective of this SBIR topic is to facilitate our efforts in creating a library of host response genes specific for each (biological warfare) BW agent. We have been using various molecular techniques to detect human cell early gene responses specific to each biological warfare agents (Das et. al, 1998; Ionin et. al, 1999). The goal is to determine a pattern of gene expression changes in response to each BW agent and to use that pattern to identify the course of impending illness. Some information that could result from this type of analysis may include exposure doses, individual susceptibility to the BW agent, presence of potentiating contaminants or genetically altered toxins that are not identified by structural-based probes. Specifically, we are working with technology of Gene array where we screen treated and untreated samples and analyze the gene changes that are induced by each BW agent. In that process we generate a large number (100s) of genes from each experiment that have to be further tested for their level of expression by northern blots or Polymerase chain reaction (PCR). We plan to use Real time PCR for quantitation of these target genes to confirm our results from Gene array studies. We have identified a panel of host genes that are up-regulated or down-regulated in response to various BW agents such as Anthrax, plague, Cholera toxin, Botulinum and 2 shock inducing toxins staphylococcal enterotoxin B (SEB) and lipopolysaccharide (LPS). For example, SEB exposure results in regulation of at least 60 different genes currently identified (Mendis et. al, 1998). The number of genes identified to be regulated by toxic agents is increasing.

We want to measure the expression of 20-40 genes per toxic agent in addition to 20-30 common response genes for all the agents. We will need to develop a system for simultaneous evaluation of expression of relevant predefined genes. We plan to develop arrays of cDNA probes, each array unique for changes in gene expression for each toxic agent. To accomplish this objective, we will require DNA standard to be prepared for each gene, designed and prepared for each agent. Standard DNAs are used for standard curves as a reference for real-time PCR for quantitative measurements. To clone and prepare standards for 100s of genes is a very tedious procedure.

Standard procedure to prepare DNA standards will require cloning in a bacteria, plasmid production, DNA isolation and purification (Sambrook et. al, 1989). This translates in to many days of labor for each gene standard. If we can avoid cloning of these genes and replace that with a simple technology where one could create genes in a test tube of known sequences, then it will make the process of gene quantitation much quicker and easier. With the advent of technologies to link DNAs to solid surfaces and other advancements in nucleic acid chemistry and replication procedures, it is conceivable to design a relatively simpler system to generate large polynucleotides in a test tube. This is not a mere procurement of a product but this technology has to be developed to allow us to clone genes in a cost and time efficient manner.

Development of simpler procedures for generating specific nucleic acids in vials instead of using standard lengthy cloning procedures have broad range of applications in other areas of military and civilian concern. If this technology can be developed, it will have a great impact on the way cloning is done in the laboratory to day. This technology can therefore be considered for the dual use science and technology (DUST) and the dual use applications program (DUAP).

PHASE I: In order to develop a technology to perform cloning in a test tube we need to explore possibilities of anchoring nucleic acids firmly to solid surface so that the anchor should be sturdy enough to withstand various manipulations of nuclei acid hybridization, denaturation and replication. Such anchored nucleic acids should be stable over long periods and be reusable for further replications. Once that is developed then one should be able to synthesize genes on these surfaces of different lengths and use these DNA again and again. We would evaluate various protocols with house keeping genes (e.g. G3PDH, PLA2, etc). Then we would eventually synthesize all these 100s of genes on this platform and generate long cDNAs. Exit criteria will be to show that the selected protocol is able to anchor oligos firmly to solid surfaces and a long gene product can be made from that while attached to the solid surface. It should work well with a few of our candidate genes in a format that is easy to adapt to our needs of generating these polynucleotides. Experimental design to prepare DNA in sufficient (microgram) quantities will also be established.

PHASE II: After the technology of cloning DNA in a test tube is established, they would prepare DNA for our already identified candidate genes of interest. Demonstrate their utility with known control materials. Use of these synthesized DNA as standards for real time PCR will be tested. Upon obtaining satisfactory results with control reagents, test the prototypes developed in our experimental systems with blood samples from monkeys exposed to the toxic agent. Exit criteria will be to supply these materials with all the reagents standardized to work well together in the form of test kits.

PHASE III: The technology of preparing long DNA polymers has broad range of applications for any set of genes of any origin. So it will be useful for both military and civilian applications. Plates could be prepared for simultaneous testing of viral nucleic acids in blood samples (HIV, HTLV, Hepatitis B and C, Herpes class of viruses etc), cytokines in different cell types, organs and or different physiological conditions and presence of food bacteria.

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KEYWORDS: Large polynucleotide generation, solid phase, fast cloning, gene, real time PCR

A01-182 TITLE: New Biosensors for Real-Time Aquatic Toxicity Monitoring

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: The objective is to develop and integrate advanced biosensor technology in a field-deployable aquatic platform to provide continuous, real time monitoring for developing toxic conditions in bodies of water that may serve as drinking water sources (e.g., streams, rivers, lakes). The platform will assess the possible impairment of our forces who may consume or contact the water during training or deployment.

DESCRIPTION: The U.S. Army Center for Environmental Health Research, in conducting research in the field of deployment toxicology, seeks new methods for real-time assessment of continuously-monitored biological endpoints to define the toxicity of environmental media. Although many chemical or biochemical sensors are being developed to detect exposure to individual toxic materials, this effort focuses on using biological responses that can identify toxic hazards that may be due to unsuspected materials or the joint action of chemical mixtures and that can complement chemical sensor technology. Technologies are sought for incorporation into a sensor platform deployed in the environment to provide continuous, real-time monitoring information. Important characteristics of the biosensor data for providing useful toxicity data are listed below. It is anticipated that more than one biosensor approach may be required to achieve these goals.

1.Sensitivity to a broad range of toxicants in water and rapid response (less than 1 hour). Through appropriate biosensor selection and interpretation, provide real-time differential responses to various classes of toxic chemicals (toxic industrial chemicals/materials and military-unique substances).
2.Minimal interference caused by variations in environmental parameters such as temperature or dissolved oxygen levels.
3.Suitability for continuous, on-line data acquisition and analyses.
4.Capability for integration in a field-deployable platform.

PHASE I: Conduct research to develop and demonstrate the efficacy of one or more individual biosensors for continuous, real-time toxicity detection. The biosensor(s) will be original or will represent significant extensions, applications, or improvements over published methods. Experimentation must show that the biosensor(s) exhibit the above characteristics. Proof of concept will be accomplished through at least one toxic exposure monitoring event identification using the biosensor(s).

PHASE II: Refine and validate Phase I biosensor(s) through testing with additional toxicants with varying modes of toxic action. Integrate additional biosensors, as necessary, to provide an array of biological indicators that will accurately identify developing toxic conditions continuously and in real time, and improve the system's ability to define the mode of action of applied toxicants. Integrate the biosensor(s) into a field-deployable platform. Specific sensors of physical or chemical water quality conditions should be added, as required, to augment the biosensors. Real-time, continuous data from the platform will be provided in a format suitable for off-platform transmission and remote analysis. The sensitivity and response characteristics of the proposed suite of biosensors will be evaluated through laboratory tests with various classes of chemicals including, but not limited to, heavy metals, organic solvents, and military-unique substances.

PHASE III: The field-deployable platform will be integrated with other similar platforms creating a network to provide early warning of developing toxic conditions in water and their potential hazard to troops. A variety of field applications are possible, including assessment of environmental hazards to troops pre-, during, and post-deployment. Field tests will apply platform/network under variable environmental conditions. The new platforms will increase the reliability and usefulness of current biomonitoring technology by substantially reducing false positives and by improving identification of potential toxic chemical hazards to troops. Also, the platforms may be used to monitor and assess the environmental impacts of military site activities and the compliance of such activities with regulatory requirements.

Field-deployable platforms capable of real-time water quality monitoring has considerable application outside the military. Watershed monitoring and assessment, now widely used by both Federal and state agencies, would benefit greatly from a network of in-stream sensors. For example, state and local agencies and municipalities (e.g, Maryland Department of the Environment and Dallas-Fort Worth, TX) have participated in EPA-funded programs that collect real-time chemical and biological information. In addition, at EPA, the National Risk Management Laboratory in the Office of Research and Development is beginning to evaluate the use of automated biomonitoring units for source water protection at drinking water facilities. Thus, development of the proposed monitoring platform would occur at a time of increasing civilian interest in just such a device.

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KEYWORDS: Biosensor, Real-time Monitoring, Continuous monitoring, Aquatic toxicity detection

A01-183 TITLE: Waterless Dialysis System

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a portable and self-contained waterless system for hemodialysis or continuous renal replacement therapy (CRRT) in the field hospital or for casualties in transit.

DESCRIPTION: Acute renal failure remains a significant predictor of mortality in trauma casualties, and treatment with hemodialysis is considerably resource- and time-intensive. Current systems also are not condusive to providing treatment in transit. With conventional "single-pass" hemodialysis technology, used dialysate is discarded--requiring 120-190 liters of purified water per treatment (which in turn is generated from 1000-1500 liters of source water). Alternatively, the used dialysate can be regenerated by passing it through a sorbent cartridge, reducing the water requirements to 6 liters per treatment. While this is an improvement, further reduction or elimination of the water requirement would have significant impact both on the resource demands and the potential for portability.

While any creative or innovative solution which meets the objectives is acceptable, it is expected that successful submissions will be adaptations of either or both of two current technologies: (a) sorbent cartridge dialysis (Refs. 1 and 3) and (b) bioartificial hemoperfusion devices (Refs. 2 and 4)

The proposed system should have a zero or near-zero (< 1 liter/treatment) dialysate water requirement while providing adequate metabolic control for critically-ill casualties with acute renal failure. It should be sturdy, lightweight, and carry a small enough footprint that it can be used for treatment of casualties in transit. It should have volumetric ultrafiltration control in order that fluid removal from the patient can be carefully regulated. It should be capable of both hemodialysis (blood flow rates=250-350 ml/min for hemodynamically stable patients) and CRRT (blood flow rates=100-200 ml/min for hemodynamically unstable patients). It should have a simple (preferably visual) means of indicating when the dialysis cartridge or regenerator needs to be replaced.

PHASE I: Development of system concept and validation using suitable patient surrogates (batched blood and animal studies). The system should meet the above criterion for dialysate conservation (< 1 liter/treatment in a equivalent human patient). The system should demonstrate capability of adequate metabolic control with the following targets: normalized (dimensionless) urea

clearance > 1.0, serum potassium < 5.5 mEq/L, serum bicarbonate > 20 mEq/L. The safety of the regenerated dialysate must be demonstrated by content analysis, using national standards for dialysis water dervied by the Association for the Advancement of Medical Instrumentation.

PHASE II: Development of prototype unit to include volumetric flow regulation and CRRT mode. Volume removal should be achievable in a range of at least 0-1000 ml/hr, with < 10% deviation from desired to actual rate. Blood flow rates for hemodialysis mode (250-350 ml/min) and CRRT mode (100-200 ml/min) should likewise show < 10% deviation from desired to actual rate. Other pertinent design characteristics are durability and portability. At the conclusion of this phase, there should be completion of necessary work for submission of prototype for FDA approval.

PHASE III: Clinical testing of unit in chronic and acute hemodialysis patients. A waterless dialysis system will have commercial applications in humanitarian and disaster relief endeavors, developing nations, and home dialysis.

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KEYWORDS: hemodialysis, continuous renal replacement therapy, water conservation

A01-184 TITLE: Robotic Medic Assistant

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PM Medical Communications for Combat Casualty Care

OBJECTIVE: To design, model, and prototype an intelligent autonomous prototype robotic medic or system of robots that can assist civilian emergency personnel or the military in locating, stabilizing, and recovering sick, wounded or otherwise injured personnel in hostile or caustic environments.

DESCRIPTION: Buddy treatment, first responder combat casualty care, and patient evacuation under hostile fire have compounded combat losses throughout history. Force protection of military first responders is complicated by increased involvement in peace keeping operations, counter terrorism, and humanitarian assistance missions that involve politically sensitive low intensity combat and combat in urban terrain; these operating environments may include abandoned minefields and contamination by weapons of mass destruction. Much progress has been made over the last 20 years in the areas of robotics; artificial intelligence/intelligent systems; sensors; computer vision; mechanical, electrical and biological engineering; noninvasive diagnostics; and wireless digital communications. The military has invested significant research funding in autonomous vehicles, urban robot projects and in sophisticated tele-robotic surgery systems aimed at both augmenting a surgeon's skills and extending his reach. Academic institutions have demonstrated intelligent robots that perform functions ranging from performing mechanical repairs to playing soccer. However, significant research needs to be performed in adapting, integrating, or developing new robotic technologies to locate, identify, approach, examine, treat, and recover human patients; to coordinate and control teams of robots to perform multifunction missions (e.g. finding patients, identifying them, assessing their physical condition via noninvasive sensors, applying basic first aid, protecting patients, lifting/moving/recovering patients, etc); and to make those robots sufficiently autonomous and survival to perform reliably under combat and/or civilian emergency conditions. This robotic medical assistant or team of robotic assistants should be able to perform noninvasive cursory physiological assessments, administer simple life saving first aid (e.g. clear the airway; stop the bleeding), and then transport the patient to a safer environment where further care can be administered by appropriate medical personnel. The basic functional requirements should include noninvasive physiological assessment; logical case analysis and triage; basic life saving first aid; and limited distance, rough terrain, patient transport. A key objective is to leverage similar robotics research being performed by government laboratories, universities, and private industry for such sponsors as the Defense Advanced Research Projects Agency (DARPA), the Joint Special Operations Command, and the National Aeronautics and Space Administration (NASA). However, none of these robot prototypes are both sufficiently rugged to operate and survive in all types of combat and civilian emergency environments, nor sufficiently autonomous to enter a building that has not been previously mapped or modeled and proceed to search for, find, and evaluate combat casualties; provide some basic first aid measures; and then evacuate them from the building. If teams of robots are to be used, significant research issues exist in command, control, and coordination among robots and robot teams for assessment, care, and recovery of wounded or injured personnel. Specific technical research challenges yet to be solved include development of devices and algorithms or heuristics to 1) plan and execute search, determine approach and

regress routes, and locate patients in all weather condition, within both urban and wilderness terrain, and without preloaded maps or terrain models; 2) conduct image pattern matching for patient and wound identification; 3) communicate with and facilitate communications between patients and human medics; 4) execute command, control, and coordination of individual robots and robot teams; 5) perform noninvasive "stand-off" smart sensor physiological assessment (including hemorrhage detection, location, and assessment of intensity); 6) analyze and make decisions on appropriate first aid measures; 7) conduct first aid; 8) lift, move, drag, tow, or otherwise effect recovery of patients from hazardous to safe locations; 9) conduct survival, evasion, escape, and self defense for both the patient and the robots; 10) provide all weather, all terrain robot and robot team mobility; 11) detect and avoid hazards or hostile situations; and 12) plan and conduct recovery from errors or the unexpected.

PHASE I: Conceptual and technical models which identify and translate functional requirements into implement able technical robotic medic designs which demonstrate feasibility of the concepts and capabilities defined in the Description paragraph above and in the Phase II demonstratable tasks below.

PHASE II: A working laboratory prototype robot or team of robots, which implements the model and demonstrates the concept. The prototype should be able to demonstrate a representative sample of the following tasks:

a. find patients in urban and field terrains.

b. identify patients as friend or foe.

c. communicate with and facilitate communications between patient and medic.

d. Assess patient to determine via noninvasive methods whether the patient is alive or dead, determine most critical injuries, perform remote triage (expectant, immediate, routine).

e. perform some simple first aid functions such as clear the airway, apply pressure bandage, inject narcotics or hemorrhage retarding drugs (e.g. Factor 7), immobilize serious fractures, etc.

f. Protect patient from further injury and from hostile attack.

g. Lift, move, carry, tow, or otherwise execute patient recovery from hazardous to safe areas where they can be attended by human medics.

PHASE III: A ruggedized fieldable prototype system ready for demonstration and limited operational testing in an Advanced Technology Demonstration (ATD), Advanced Concept Technology Demonstration (ACTD), and/or Advanced Warfighting Experiments (AWE) as well as in civilian emergency response scenarios. Once validated conceptually and technically, the dual use applications of this technology are significant in the area of civilian emergency services (e.g. finding, treating, recovering injured personnel in mine, construction site and nuclear power plant accidents; chemical spills; fire fighting, terrorist, hostage, situations; and in police response to situations involving armed suspects. This technology could potentially save many lives among military and civilian emergency medical personnel as well as among the casualties and injured persons they are assigned to help.

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2) References that support the robotic medic objectives are available upon request and from the Army Informatics Medical Emergency Decision Tools (IMEDTools) MEDBOT Program, c/o Dr. Lyn Yaffe, Illinois Institute of Technology Research Institute (IITRI) 6000 Executive Blvd., Suite 519, Rockville, MD 20852

KEYWORDS: Medical robotic assistant, MEDBOT, robotics, combat casualty care, combat health service support, artificial intelligence, telesurgery, non-invasive sensors, emergency resuscitation, trauma care, first aid, combat in urban terrain (or urban warfare).

A01-185 TITLE: Monoclonal Antibodies Suitable for Identification of T and B Lymphocytes in Rabbits and Guinea Pigs by Flow Cytometric Analysis

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Generate monoclonal antibodies that identify surface proteins and intracellular cytokines for both rabbits and guinea pigs. This will allow for discrimination of lymphocyte subsets and identification of memory cells responding to booster immunizations in these animal models

DESCRIPTION: Currently the only immunological correlate for determining the level of protection elicited by a vaccine is measurement of antibody levels by ELISA or neutralization assay. Research has shown that protection exists, however, even when antibody levels have waned. Therefore it is imperative that new means be found to measure the immunological memory so that booster immunizations can be administered when necessary. Recent advances have provided new means for identification of

immunological correlates by identifying the cells involved in the maintenance of immunological memory. Memory T- and B-lymphocytes can be identified based on expression of surface proteins and production of cytokines. While reagents exist for such studies in mice and humans, reagents are lacking for other species that are commonly employed as animal models. Monoclonal antibodies are needed that are suitable for flow cytometric analysis of lymphocytes from Hartley guinea pigs and New Zealand White rabbits. Ideally, these monoclonal antibodies should recognize surface proteins that are the rabbit and guinea pig equivalents of CD3, CD4, CD8, CD20, and CD69 in humans. For identification of memory T lymphocytes, additional monoclonal antibodies are needed that recognize interferon-gamma, tumor necrosis factor alpha, and interleukin 10. Once these antibodies have been generated the contractor would be able to sell these reagents commercially to researchers worldwide. Rabbits and guinea pigs are important animal models for a number of human diseases and new reagents for dissecting the immunological response in these animals would be very useful.

PHASE I. Immunize mice or rats with either lymphocytes or purified proteins from rabbits and guinea pigs. From these immunized animals generate panels of hybridomas that produce monoclonal antibodies that recognize surface proteins on rabbit and guinea pig lymphocytes by flow cytometric analysis. Identify monoclonal antibodies that recognize established markers of T- and B-lymphocytes including CD3, CD4, CD8, CD20 and CD44. Confirm that the proteins recognized by the monoclonal antibodies are the rabbit or guinea pig homologs of the mouse & human molecules. Demonstrate the utility of these antibodies to discriminate between subsets of rabbit and guinea pig peripheral blood lymphocytes by multi-color flow cytometric analysis. Purify milligram quantities of monoclonal antibodies and conjugate to fluorescent molecules (FITC, PE, Cy5, APC) for use in flow cytometric analysis.

PHASE II: Generate panels of hybridomas that produce monoclonal antibodies that recognize cytokines produced by mitogen-stimulated rabbit and guinea pig lymphocytes. Identify monoclonal antibodies that recognize interferon-gamma, tumor necrosis factor alpha, interleukin 4, and interleukin 10 by immunoprecipitation and western blot hybridization. Confirm by amino acid sequencing and comparison with human and mouse sequences. Demonstrate the suitability of these antibodies by intracellular cytokine staining of mitogen-stimulated lymphocytes by multi-color flow cytometric analysis.

PHASE III: These monoclonal antibodies could be used in a broad range of military and civilian biotechnology applications. Rabbits and guinea pigs are widely used as animal models and the availability of these reagents would greatly facilitate such studies.

KEYWORDS:
monoclonal antibodies, lymphocytes, ELISA, neutralization assay, immunological memory

A01-186 TITLE: Dedicated Computational Microsystems for Biomedical Sensors

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: Develop novel computational methods for extracting biomedical information from electrophysiological sensors and pulse, activity and other waveforms in noisy environments, and implement these as integrated subsystems of individual micro-power dispersed "smart sensors" with minimal spatial and bandwidth footprint.

DESCRIPTION: Sensor systems applicable to biomedical assessment and monitoring of soldiers in combat include electrocardiography, electroencephalography, electromyography, ballistocardiography, impedance plethysmography, various acoustic and cardiac pulse sensors, and, for movement and sleep estimation, accelerometers. Several technical and practical barriers are common to most or all of these systems: 1) signals are susceptible to noise, interference and artifact; 2) communication bandwidth prohibits transmission of raw signals to distant signal processing nodes; 3) local processing nodes of current design are bulky and/or power-hungry, unsuitable for low footprint sensors with a low logistical burden; 4) current methods for data information extraction are computationally intensive; for instance, such techniques as delta-band power (EEG), heart-rate variability (EKG), acoustic spectrograms (phono), and noise-elimination methods require complex software, large data sets. There is a requirement for novel mathematical and statistical approaches to sensor signal processing and analysis which are amenable to operation in situ as subsystems (firmware and/or coprocessors) integrated with individual sensors. Such approaches should address the above barriers, and lead to design and fabrication of a hybrid or application-specific micro-power sensor. Any one of the sensor systems suggested above, or others not mentioned, are acceptable targets of the proposals solicited.

PHASE I: Submit design and demonstrate in hardware and software proof-of-principle prototype assemblies and provide validation of proposed computational solutions against a benchmark of standard clinical or research methods. Considerable risk resides in negotiating the several tradeoffs identified above. For instance, an efficient algorithm which nonetheless requires a

user to hold still for 60 seconds would fail on the noise issue. Dynamic adjustment of process based on signal behavior, algorithm simplification and regenesis, temporal gating and variation of sampling rates, and attendant reliability estimation are among many approaches which might provide innovative solutions. Any single data source, among those suggested above, may be chosen to demonstrate a novel computational approach. Results will be assessed in terms of savings in computational cost factors and feasibility of implementation in low footprint sensor environments.

PHASE II: Based on success of Phase I, design and develop optimized sensor system prototypes fully reduced in size and power requirements, and fabricate prototypes sufficiently durable ("hardened") for both clinical and field testing.

PHASE III: The resulting "smart sensors" are components in networks of wearable body sensor systems with significant potential for health status monitoring in a variety of hazardous and industrial occupations. Successful low-footprint devices are likely candidates for inclusion in Warfighter Physiological Status Monitor and/or Warrior Medic sensor suites.

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KEY WORDS: Sensors, signal processing, algorithms, microelectronics, ballistocardiography, electrocardiography, electroencephalography, cardiac pulse, actigraphy

A01-187 TITLE: Active Noise Reduction Stethoscope

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: Design and construct a stethoscope employing active noise reduction to permit auscultation in the high-noise environment typified by rotary-wing aircraft.

DESCRIPTION: Medical personnel frequently have difficulty listening for breath or heart sounds in critically injured soldiers because of the noisy environment surrounding the patient. External noise enters the auscultation environment from several sources: (a) the stethoscope my not have closely fitting or deeply inserted ear pieces resulting in seal leaks which permit noise to enter directly into the ears; (b) noise enters the stethoscope as it impinges directly on the acoustic tubing leading from the stethoscope head to the ear pieces; (c) unwanted noise is picked up directly by the stethoscope head; and (d) noise and vibration are conducted through the patient's body and enter the stethoscope head at the patient-stethoscope interface. Advances in stethoscope design have solved or have the capability to solve some of these problems. Loose-fitting ear pieces may be improved or replaced with insert ear pieces such as the Communications Earplug used in Army aviation for improved hearing protection and communication. Electronic stethoscopes are being developed which minimize the use of acoustic tubing, transmitting electrical signals from the head to the ear pieces instead of transmitting acoustical signals. The problems at the stethoscope head have not been solved, however. It is possible that a highly effective shield, analogous to an ear cup used in circumaural hearing protective devices may reduce the air-transmitted noise picked up by the stethoscope head. This cup needs to have significant noise reduction capabilities as well as having a flexible seal to permit contact with the patient without developing seal leaks. However, significant amounts of acoustics energy will be picked up using a "perfect" stethoscope head cup from noise impinging on the patient's body or vibration traveling through the litter. The reduction of the noise traveling through the patient's body will require active noise reduction/cancellation techniques that are not available in current auscultation devices.

PHASE I: Conceptual design and construction of a prototype of a stethoscope using active noise reduction/cancellation technology. The device should have no acoustic tubing outside of the stethoscope head and should permit the use of foam-insert type ear pieces.

PHASE II: Submit the prototype stethoscope for airworthiness testing at the USAARL Aeromedical Certification and Evaluation (ACE) laboratory. Resolve technical problems identified by USAARL ACE and the contractor. At the end of Phase II, the prototype will be delivered to USAARL for operational testing and evaluation in rotary-wing medical evacuation aircraft. Airworthiness and operational testing and evaluation will be performed at no cost to the SBIR contractor. All test results will be provided to the SBIR contractor.

PHASE III: A device that will permit useful auscultation in noisy environments will be useful in many military and commercial venues. If such devices will permit accurate detection and recognition of normal and abnormal breath, heart, and Korotkoff sounds in the rotary-wing aircraft, they will also be useful in fixed-wing air medical transport and battlefield medical transport as well in civilian ambulances and other noisy environments.

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KEYWORDS: Auscultation, Active Noise

A01-188 TITLE: Development of Thermally and Photochemically Stable Anesthetic Components

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To design and synthesize novel vasoconstrictors to be used in local anesthetic formulations. These compounds will resist thermal and photochemical degradation when exposed to far-forward environmental conditions.

DESCRIPTION: Amide-based local anesthetics employed for dental and medical applications are ubiquitous pharmaceuticals in the private sector and in the military. The anesthetic component is generally lidocaine or mepivacaine hydrochloride salt administered as an aqueous solution in the presence of a water-soluble phenethylamine-type vasoconstrictor (usually epinephrine bitartrate). Although the anesthetic is relatively stable to harsh environmental conditions, the rate of vasoconstrictor degradation is accelerated upon exposure to above ambient temperatures and direct sunlight. Previous investigations suggest a correlation between the loss of vasoconstrictor in amide-based local anesthetics and loss of efficacy. Evidence also suggest a major thermal pathway for destruction of the most common vasoconstrictor (epinephrine) in local anesthetic injections is racemization, possibly via acid-catalyzed hydrolysis. The purpose of this SBIR topic is to design and synthesize robust vasoconstrictors for use in local anesthetic injections. Novel vasoconstrictors will adhere to four criteria; the compounds must: 1) exhibit alpha-adrenergic properties similar to epinephrine when injected locally, with minimal or no beta-adrenergic activity, 2) resist acid-catalyzed hydrolysis, 3) retard the rate of systemic absorption of the anesthetic, and 4) experience little or no photochemical destruction. Successful SBIR candidates must have expertise in drug design, asymmetric synthesis, purification and characterization of small organic molecules. Candidates must also have the ability to biologically assay the receptor affinities of novel compounds.

PHASE I: Determine the feasibility of designing potential vasoconstrictor candidates for use in local anesthetic formulations. Phase I will also entail developing asymmetric synthetic strategies for lead compounds which may include the use of chiral starting materials, chiral auxiliaries or separation methods using chiral chromatography.

PHASE II: Synthesize lead vasoconstrictors using modern synthetic methods, instrumentation (1HNMR, 13CNMR, high resolution GCMS) and chromatographic techniques (LCMS, HPLC). Perform biological assay on receptor affinities for enantiomerically pure compounds via displacement of specific radioligands in vivo. Investigate toxicology studies in anticipation of FDA approval.

PHASE III: Many third world countries do not have climate-controlled environments to safely store pharmaceuticals. Transport and storage of anesthetics to these regions, especially in hot climates, may compromise the efficacy of the drug. Development of new anesthetic components would be of great benefit to the oral care of many civilians in these nations, as well as military personnel deployed in austere environments.

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KEYWORDS: Asymmetric synthesis, anesthetics, phenethylamine, dentistry

A01-189 TITLE: Development of an Operational Visual Disability Glare Tester

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Acquisition Program

OBJECTIVE: Develop an ophthalmic instrument that measures forward (glare) and backward (haze) scatter in the eye and allowing for the control of the amount of glare and haze while measuring, at a minimum, focal (landolt ring) and full field (sine wave grating) contrast sensitivity. This instrument should allow a direct measure of visual performance under objective, quantifiable at least on an interval scale, measures of experimenter controlled levels of glare and haze that mimic operational environments.

DESCRIPTION: Cataracts, refractive surgery and other ocular conditions have been known to cause an increase in glare disability. The main source of visual disturbance is the presence of scattering particles in the eye (cataracts or corneal opacities) or changes in the aberration structure of the eye (refractive surgery or keratoconus). Contact lenses, spectacles, visors and eye protection devices (such as protective mask outserts or laser protective eyewear) can also cause glare that can have a significant impact on vision and the performance of military operations. Examples of glare sources in the operational environment include lights around landing fields, vehicle lights, and the sun. Most glare testing devices use a low contrast visual chart and a bright light source to produce glare near or around the chart. Some glare sources are placed near the eye and a chart is viewed at a distance. In all cases, the light source causes the pupil of the eye to constrict, which is not the case in the natural environment when the lights are at a distance, close to the object of regard. The use of dilating drops to overcome this reaction to the light source is not a proper solution, in that it changes the overall optics of the eye and does not mimic how the eye must function in the environment. A device is needed that presents glare to the eye and measures changes in visual performance without changing the optical parameters of the eye while closely approximating the functioning of the eye in the operational environment. This device should not only measure changes in visual performance but also measure the amount of forward and backward scatter in the eye.

PHASE I: Investigate innovative approaches to presenting glare, measuring light scatter in the eye, and testing for visual impact; requires concept exploration, review of current literature, feasibility study and development of proposed system architecture/algorithms.

PHASE II: Fabricate a prototype for laboratory and operational evaluation to include accuracy of intraocular scattered light measurement, comparison with current glare test units, correlation with visual tests and relation to visual impact of glare in the operational environment.

PHASE III: This technology would have immediate application in the civilian sector, as refractive surgery is becoming an increasingly common procedure and the early and accurate detection of visual impact due to any refractive procedure or cataracts is an important public health issue. Military applications of the glare device include the screening for and follow-up of operationally significant levels of glare, halos or forward light scatter of the eyes secondary to ocular changes due to aging, surgery, degenerative processes or physiological responses to environmental exposures. Some specific conditions include exposure to altitude, ultraviolet or infrared radiation, humidity, heat, cold or chemicals. Additionally, changes in corneal clarity due to the effects of fatigue, dehydration or stress can be monitored or appropriate interventions applied.

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KEYWORDS: glare disability; visual performance

A01-190 TITLE: Catheter Insertion Simulation for Epidural Anesthesia and Spinal Tap

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To demonstrate the advanced development of a virtual workbench simulation device for simulating catheter insertions for epidural anesthesia and needle insertions for diagnostic lumbar puncture (spinal tap).

DESCRIPTION: A full performance virtual workbench simulator for training catheter insertions for epidural anesthesia and needle insertions for diagnostic lumbar puncture. Applications are for both wartime and peacetime trauma diagnosis and management, as well as civilian applications for surgical, obstetric and diagnostic use.

The following performance objectives should be met:

1. The simulator will provide visual and tactile feedback consistent with the placement of a spinal needle and epidural catheter in an adult patient.
2. The simulator will have qualities allowing the user to palpate bony landmarks along the entire axial skeleton.

3. The simulator will allow for the use of a variety of spinal needle sizes and types, both plastic and glass syringes, and various catheter sizes.
4. In addition to the virtual representation of the patient, fluoroscopic and 3-D bone views demonstrating real time needle position should be included.
5. The user interface should have a capacity for altering patient condition, inducing complications and the ability to change the patient's position in space.
6. The user interface should consist of a teaching, rehearsal and testing module that can be followed in real time by an instructor as well as saved for future use.

PHASE I: Develop the concept and design a prototype of a virtual workbench simulator for training catheter insertions for epidural anesthesia and needle insertions for diagnostic lumbar puncture.

PHASE II: Develop and demonstrate a functional prototype of the virtual workbench simulator. Develop a software Application Programming Interface (API) that will enable the development of individual simulation applications. This prototype should include at least the capability to simulate needle / catheter insertion in at least a normal adult axial skeleton (including soft tissues from the skull base to the pelvis and sacrum).

PHASE III: This virtual workbench simulator is applicable to individual military and civilian simulation training in the use of needle insertions for diagnostic lumbar puncture and catheter insertions for epidural anesthesia.

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KEYWORDS: Modeling and simulation, medical skills training, individual and unit training, medical force readiness, mission rehearsal, epidural, spinal catheterization, lumbar puncture.

A01-191 TITLE: In-service Technique for Assessing Conditions of Ballistic Protective Inserts in Personnel Armor

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM - Future Soldier

OBJECTIVE: Develop a reliable, easy to use in-the-field, low cost, non-destructive technique to assess the condition (as related to ballistic performance) of personnel armor ballistic protective inserts that are based on ceramic/fiber-reinforced composite technology.

DESCRIPTION: The primary ballistic protection offered against small arms rounds continues to be based on ceramic with fiber-reinforced composite backing. Due to the nature of the materials used, these systems can potentially be damaged or degraded during use. As such, it is necessary to develop a method for assessing the ballistic integrity of the armor systems in the field. Because these systems are opaque, current assessment techniques, which may include x-ray, CT scan, or ultrasonic scan, are complicated. These techniques tend to require a major investment in equipment that is not readily usable in a field environment. The desired outcome of this effort is a low-cost, easy to use, non-destructive technique or method for assessing the integrity of a ballistic protective plate to have a high level of confidence and reliability that the ballistic performance has not been degraded during use and/or storage. Approaches to this effort may include hardware that is integrated into a plate during or after production or may consist of a completely external method for assessing integrity of fielded items. It is important that the method assess the overall condition of the armor item. It is anticipated that more than one component or aspect of the armor item will require assessment (e.g., the ceramic component for cracking, the bond between the ceramic and the fiber-reinforcement) to ensure ballistic performance integrity. Other desirable features may include the ability to locate a fault and the ability to apply the technique to currently fielded items. If the technique is integral to a plate technology, no significant weight penalty should result.

PHASE I: Research, develop and propose a technique/system design with the potential of realizing the goals in the description above. Develop technical specifications for components and identify as commercially available or to be developed. Conduct

necessary investigation on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed technique/system design, including mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a detailed description of the proposed technique/system to include specifications of key components.

PHASE II: Develop the technique/system identified in Phase I. Fabricate and demonstrate the technique/system, then characterize and refine the technique/system performance in accordance with the goals in the description above. Deliver a report documenting the theory, design component specifications, performance characterization and recommendations for technique/system performance.

PHASE III: A technique or system meeting the requirement outlined in this effort would be applicable in both military and civilian armor arenas. The civilian law enforcement community would reap a substantial benefit from this effort. The DoD vehicle armor area may also be able to apply this approach to their lightweight armor technologies.

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KEY WORDS: Ballistic Protective Inserts, Ceramic/fiber-reinforced composites, Non-destructive Assessment Techniques

A01-192 TITLE: Low Cost Actuators for Precision Guided Steerable Parachutes/Parafoils

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: Explore innovative technologies for actuators used to steer aerial delivery systems. Actuators steer these systems by lengthening and shortening the suspension lines which connect the delivery system to the load. A family of actuator solutions is desired which are capable of multiple actuations, are low cost, highly efficient, self energizing/regenerative, rapid acting, capable of retractions and releases of between 1 foot through as large as 20 feet and capable of pulling from several pounds (small) through several thousand pounds (large) with use and storage in environmental extremes, for airdrop applications in all environmental conditions.

DESCRIPTION: The ability to provide low cost, precision delivery of supplies to non-combatants and the US military will be enhanced with new innovative actuator technology for use in the control and steering of parachutes, parafoils and other airborne systems. Current actuator technologies are slow to react, energy intensive requiring heavy and bulky energy generators to be carried with the dropped load, or are very expensive. As US military doctrine shifts to faster movement of ground forces the necessity of using airdrop for resupply will also increase because long, ground based resupply chains will not be practical, affordable or sustainable. Fast moving ground forces can only be efficiently resupplied with accurate, steerable aerial delivery. Today's airdrop missions run the gamut from emergency aid to non-combatants to precision delivery of supplies and munitions to widely dispersed and often isolated US military forces and for humanitarian relief. These missions are expensive due to aircraft operating and support costs, the loss of aircraft due to enemy fire, the supplies, which are airdropped, the supplies, which are lost or retrieved by adversary groups, and the actual airdrop equipment such as parachutes which is expended for these drops. Current high altitude airdrop capabilities provide a low likelihood that the supplies being airdropped will land within a reachable distance to the intended recipients. Airdrop resupply missions are expected to increase in the future as the US military takes on more humanitarian missions and as the US military reconfigures itself into a force capable of rapid movement and force projection. These missions and force configurations will require that the military moves quickly and accurately to get the supplies and munitions exactly where they are needed, when they are needed. The following actuator concepts will be considered, but

concepts should not be limited to these: pneumatic, electric or other power sources for the actuators, materials whose mechanical properties and dimensions change with the application of electric current. This investigation will serve as the basis for planned programs in PM-Soldier Support such as the FY03 PEGASYS program which will develop a family of autonomous air delivery systems over a wide range of weight, offset and controllability ranges.

PHASE I: New solutions and innovative concepts and technologies for airdrop actuators will be explored. The actuator's performance characteristics are desired and should be documented through analysis and modeling. Repeatability, power usage/storage, system weights, cost, ease of maintenance, and flexibility will be some of the factors used to judge the proposed solutions. Contractors will have great flexibility in formulating innovative approaches for actuators. The Government has no preconceived notions or restrictions about which technologies should be developed. There is no existing stockpile of actuators that must be used or disposed of before adoption of new actuator technology. The most promising technologies identified in Phase I will be matured to demonstrate prototype actuators.

PHASE II: The actuator's performance characteristics are desired and the analysis and modeling performed in Phase I should be demonstrated with a prototype in Phase II. The Government will make GFE available to the Offeror for proof-of-concept demonstrations. Develop manufacturing techniques, fabricate and test full-scale prototype systems to ensure satisfactory performance in all operational and performance environments. Development of a life cycle cost estimate for production of the proposed actuator solutions should be considered.

PHASE III: Incorporate prototype airdrop compatible actuators into prototype airdrop systems. Adaptability of the solution into guidance, navigation and control algorithms should also be considered. The goal is to transition this technology into existing and future airdrop systems. Integration into existing or soon to exist precision airdrop platforms will be done in partnership with the government if Phase II is successful. This technology has applications for all humanitarian relief, military airdrops of supplies/equipment. The actuator technologies developed will be used to create a fleet of parachute/parafoil born payloads such as weapons, robots, sensors and other items that can deliver these payloads from a standoff distance when needed. The actuator technologies developed are expected to have an enormous range of applications to include space applications, robot actuation, human motion enhancement, human strength enhancement, commercial machinery and potentially recreational equipment and other commercial uses. Actuator technologies developed by this SBIR may have applications to aircraft. By their nature, spacecraft and aircraft can be improved anytime a component can be made lighter or can be made to require less power to operate. Ground and water vehicles also require actuators to move a variety of components.

Operational and Support Cost Reduction (OSCR): This technology is a critical component of the operating and support costs associated with all future humanitarian and military airdrop operations. Development of this technology will minimize the percentage of costs due to humanitarian aid supplies that are lost or dropped into areas where the intended recipients cannot venture for fear of reprisals. Development of this technology will reduce the amount of supplies needed to be airdropped during military missions because of increased certainty of delivery to the desired recipients, therefore, minimizing the number of sorties needed and the risks exposed to transport aircraft and crews. This technology will allow aircraft to drop more cost effective systems from higher altitudes and further away from the target zone which will reduce the risk to the aircraft as well as allowing the aircraft to carry out multiple drops in a shorter time. The alternative to airdrop supply/resupply is ground based supply chains. These supply chains will have to keep up with current and future fast moving ground units. In the future, individual soldiers, small units, artillery and vehicles will be widely dispersed as technologies such as Land Warrior and newer command and control equipment emerge and are fielded. Ground based resupply chains will be hard pressed to keep up with these widely dispersed assets without autonomous high altitude deployable affordable airdrop systems. Commercial space, air, water and ground vehicles will all be able to take advantage of lightweight, low cost, self powered, regenerative actuators. Actuator technologies developed by this SBIR may have applications to aircraft. By their nature, spacecraft and aircraft can be improved anytime a component can be made lighter or can be made to require less power to operate. Ground and water vehicles also require actuators to move a variety of components.

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KEY WORDS: Actuator, parachute/parafoil, rapid response, autonomous airdrop system, guidance, navigation and control.

A01-193 TITLE: Airdrop Technology and Systems to Prevent Payload Rollover

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: Develop technologies/systems to minimize the potential for rollover of airdropped payloads upon ground impact.

DESCRIPTION: Damage or destruction of airdropped cargo due to rollover upon landing remains a chronic problem in airborne operations, resulting in mission degradation that could potentially jeopardize mission success. The loss or degradation of equipment due to rollover can result in a force less able to cope with the enemy threat. Similarly, the time spent by troops on the drop zone righting overturned cargo items can greatly increase their risk to enemy fire. There is need for improved techniques to study the rollover phenomena, in order that systems/methods can be devised to minimize the potential for platform/payload overturning. This effort will, therefore, focus on the development and verification of system concepts and technologies to improve overall anti-rollover performance, and will include development and testing of both scaled, and potentially full scale, prototypes.

PHASE I: This phase will focus on the development of system concepts to minimize the potential for platform/payload rollover. Trade-off studies will be conducted to determine the relative cost and performance benefits obtained through incorporation of various anti-rollover technologies into several representative cargo items currently airdropped. It is envisioned that these trade off studies will be conducted using either offeror developed analytical tools or through adaptation of a commercially available computer code. These computational tools should permit one to analyze/bound the effect variables, such as cargo weight and geometry, vertical and horizontal impact velocity, platform orientation relative to the horizontal velocity vector, and the nature and slope of the terrain, have on system performance. Analytical techniques will be validated by means of scale model tests of the systems chosen for study. Included among the concepts to be explored are use of deployable, pressurized air beam outriggers, or an airbag skirt, use of sensors/actuators to align the platform's strong axis perpendicular to the direction of the horizontal velocity vector to minimize the potential for overturning, and possibly other offeror proposed concepts. The final report will include results and recommendations based upon Phase I findings, and provide a follow-on plan for Phase II full-scale prototype tests, including needed instrumentation and properties for validation.

PHASE II: An in depth review of the Phase I report will be conducted by Airdrop Technology Team (ATT) personnel. If the technology shows promise, and appears practical, full-scale prototypes of the most promising anti-rollover system(s) will be fabricated. Controlled, instrumented testing of the prototype system(s) will then be conducted, over the full range of variables previously discussed, to verify the concepts potential, refine the analytical techniques/tools developed in Phase I, and demonstrate the system's feasibility. Based upon a comparison of Phase II test and analytical results, a report will be prepared detailing findings with recommendations for any further refinements needed to improve test/analytical correlation.

PHASE III: Anti-rollover system technology could find its way into the automobile industry where the technology could be used to prevent vehicle rollover during sudden, evasive maneuvers. Sport utility vehicles (SUV's), for example, which have a much higher center of gravity than conventional automobiles, and therefore, are more prone to overturning, represent a lucrative segment of the commercial auto market where this technology could find application.

KEY WORDS: airdrop, rollover, ground impact, modeling, air beams, airbags, impact attenuation

A01-194 TITLE: Non-powered Condensation Control Mechanisms for Shelters

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: Investigate fibers and materials whose moisture transport behavior will manage severe condensation in tents or rigid-wall shelters. The objective is to develop a passive system that can retain and redirect moisture accumulated on the ceiling and walls retaining and redirecting it outside or to the ground.

DESCRIPTION: The introduction of synthetic, coated fabrics have extended the life expectancy of tent fabrics compared to the natural fiber based canvas fabrics. Unfortunately the coatings that provide excellent waterproof protection from the rain also keep moisture inside of the tents that in many field environments cause significant condensation to accumulate. This condensation then forms droplets and it literally can "rain" inside of these shelters on occupants and electronic equipment. Obviously this degrades both the soldiers quality of life while damaging mission equipment and documents (maps, etc.). This problem has resulted in numerous complaints from the field.

The goal of this project is to control the accumulation of condensation through passive means. The apparel and health industries have maximized the use of wicking and moisture transport fibers, breathable films and super absorbents to remove moisture in contact with human skin. These passive mechanisms offer the potential to transport condensation in tents away from roofs and walls.

PHASE I: Explore potential fibers, films, coatings and materials that when combined or used alone can retain and redirect moisture as it accumulates on tent ceilings and walls. Characteristics such as weight, bulk, cost and ease of manufacturing will be considered in the trade-off analysis. Fabricate samples of various promising combinations and test for efficiency.

PHASE II: Further develop the best product(s) from phase I, scaling-up manufacturing methods if necessary. Fabricate full-scale prototypes and conduct full-scale testing.

PHASE III: Condensation is an issue in any fabric or rigid structure that is not well insulated or ventilated. Fabrics are being incorporated into many permanent commercial structures. Dual-use applications include any tensioned fabric structure, special-event rental tents, emergency/disaster relief shelters and camping tents.

KEY WORDS: condensation, moisture, textiles, fibers, wicking, moisture-transport, super absorbents

A01-195 TITLE: Dual-use Durable Water Repellent and Anti-chemical/biological Agent Treatments

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

ACQUISITION PROGRAM: PM-Soldier

OBJECTIVE: To develop durable hydrophobic, oleophilic water repellent treatments for fiber/fabric suitable for use in outerwear and chemical protective clothing for the individual soldier.

DESCRIPTION: Currently, the use of fluorocarbon based hydrophobic and oleophobic treatment is used to impart durable water repellency for both standard outerwear and chemical protective clothing items. Although, these water repellent treatments are considered durable, their durability varies greatly based on the fiber content of the material. The water repellents do not offer the same degree of water protection on 100 % synthetic fiber garments as they do on cotton/synthetic fiber blend, due to the inability of these fibers to bind strongly with the fluorocarbon compounds. Consequently, the water protective properties of 100% synthetic items need to be restored frequently to maintain the level of water protection needed by the individual soldier. The restoration procedure is both costly and time consuming and if not applied when needed, it could expose the soldier to potential environmental hazards. Furthermore, all existing water repellents exhibit virtually no durability whatsoever to drycleaning. The need exist for water repellents that are truly durable to washing and drycleaning for all fibers.

For many years, both hydrophobic and oleophobic properties were required for chemical protection. Recent studies indicate that although hydrophobicity is still required, an oleophilic material might provide better chemical protection and thus preferred over the current oleophobic material. Although, existing silicone-based water repellent do offer combined hydrophobic/oleophilic properties they have very limited washing and drycleaning durability.

This topic focuses on the development of a new classes of innovative materials such as polydichloroacetylene and others that provide enhanced hydrophobic, oleophilic properties by virtue of their covalent bonding capability to fiber surfaces, thus significantly prolonging the durability to multiple washings and drycleanings. Polydichloroacetylene can also be activated by heat to produce small amounts of chlorine at the surface for controlled sterilization and chemical agent abatement. Based on their durability, this technology could also be extended to standard rainwear and outerwear.

PHASE I: Identify chemical structures with the desired mechanism to provide water repellency properties durable to both laundering and drycleaning. Based on current scientific literature, develop formulations and processing techniques for new classes of durable water repellents that will improve water resistant and chemical protective properties on appropriate textile materials. Complete a preliminary evaluation of treated materials for pertinent water and chemical protective properties using standard laboratory test methodology for spray rating, dynamic absorption, simulant and live agent testing, etc., in order to show that the chemical formulations are feasible candidates for Phase II.

PHASE II: Optimize the chosen formulations and processing techniques for selected fabrics. Test treated fabric to demonstrate that the new prototype water repellent treatments for fiber/fabric provide a durable, water repellent, material that meets or exceeds the stated performance requirements.

PHASE III: Ongoing concerns over the use of chemical and/or biological agents by terrorists or accidental release of hazardous materials establishes a need for multi-functional durable water repellent treatments for use by local, state, and federal emergency response agencies. Applications include commercial rainwear, hospital wear, tents, shelters, and canopies.

REFERENCES:

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2) Santos, L. Performance Requirements for Fiber/Fabric Water Repellent Treatments. (unpublished, available from DTIC under the topic number at the SITIS website: http:www.dtic.mil/dtic/sbir)

KEY WORDS: Durable water repellent, bacteriocidal, hydrophobic, oleophilic, heat-activated sterilization

A01-196 TITLE: Development of Enhanced Chemical Biological (CB) Closure

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

ACQUISITION PROGRAM: PM Enhanced Soldier Systems

OBJECTIVE: To develop miniaturized CB/ water-tight closure

DESCRIPTION: Recently developed CB uniforms incorporate state-of-the-art, seam-tape capable, light-weight materials offering complete protection from direct liquid, vapor and aerosol exposure. All CB suits are evaluated in final design for 'Man In Simulate Testing' (MIST). The front entry closure system has been water-tight closures from the commercial dry-suit market. However, although these closures pass evaluation of MIST, they are incompatible with the uniform since they are for heavy-duty application. Consequently, these closures possess a slider resistance that is extremely high (enough to rip the outer shell fabric). The closure tape stiffness overwhelms the CP uniform outer shell fabric and due the extreme thickness of the closure tape, it is difficult to seam-tape and in some cases the seam-tape fails to stick properly. Furthermore, these closures are costly at about $1. per inch.

Ongoing Thrust: The primary thrust of this proposal is tied to the development of a multi-service Army / Navy 'Waterproof CB Resistant Closure Suit' which incorporates a selected lightweight permeable membrane that does not use carbon base coating. Purpose of suit is to reduce weight, increase flexibility, provide ability to seam tape and be breathable. However, the suit shall be totally waterproof, including closures. The suit has been using a commercially available dry-suit diving closure. However, this closure totally overwhelms the base lightweight outer shell fabric of the CB uniform since they are hard to open/close, very stiff due to there extreme thickness, difficult to vacuum package due to stiffness and uncomfortable to wear, but they do pass all CB protection requirements. Purpose of this SBIR is to develop a miniaturized closure system to reduce cost, improve seam tape capability, flexibility, comfort, donning/doffing, packing size and weight without sacrifice to CB protection.

PHASE I: Overall requirements for the proposed SBIR would be to provide for a miniaturized water-tight closure with an engagement/disengagement mechanism in a commercial size range of small to medium with a significantly reduced cost. The minimum crosswise strength shall be 145 lbs. per inch, offer resistance to liquid, as well as vapor chemicals, be hydrostatic resistant at 50 cm. for 10 min. period in both a relaxed and in a 10 lb. cross pull mode of the opposite tape sides. The engagement

mechanism shall have a pull strength of 2.0 pound (max.) resistance, be available in separating configuration, and use a lightweight highly flexible closure tape that offers a seam tape capability at 5 lb. (min.) peel resistance. Design for Phase I shall incorporate use of single engagement mechanism in conjunction with a means to separate the closure (pin & box, etc). Technical barriers include design of separating unit, lower pull resistance, selection of materials to offer CB resistance and be seam-tape capable.

PHASE II: Finish with addition of second engagement mechanism in a mouth to mouth arrangement or means to open closure from either end. Develop manufacturing techniques, and fabricate a prototype or prototypes. Demonstrate that the prototype based on the Phase I concepts satisfy the performance requirements. The prototype may be applied to one or more end-items to facilitate the performance demonstration.

PHASE III: The closure will be applied to a new generation CB uniforms, rainwear, CB/general field tentage, equipage, tarps (weapon covers), underwater usage or other end-items for field testing. Development of manufacturing equipment for large scale production of miniaturized closure will be done in Phase III. Closures shall be used on an array of commercial tentage, equipage, wet / dry suits, truck / boat covers, nuclear suits, tarps, bags or other protective applications.

REFERENCES:
A-A-55634 -Commercial Item Description (CID), "Zipper closures." (reference obtainable from Norma Scott, phone: 508-233-4185, fax: 508-233-4097)

KEYWORDS: closure, chemical biological, zipper, self-seal, water tight, seam tape

A01-197 TITLE: Anchoring Technology for Deployable Structures

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: To reduce the manpower requirements for anchoring deployable structures and shelters, and to improve the efficiency of such anchoring systems through application of new technology or creative adaptation of current advanced technology. Possible approaches include utilization of one or more of the following: novel anchor designs, new emplacement methods, soil stabilization techniques, lighter weight high strength materials, polymer soil gripper/adhesive that can be reversed via phase change.

DESCRIPTION: For large shelter complexes, such as Force Provider and Deployable Medical Systems, and for large shelters such as those used for aircraft and vehicle maintenance, anchoring is a repetitive, time-consuming task, yet vital for the structural stabilization of the shelter. Shelter complexes can cover up to 4 acres. In wet, muddy, and sandy soils, ground anchors must be driven deep into the ground to provide sufficient holding power, and even then the efficiency of the anchors is far from optimal. Erecting large shelters on concrete or asphalt surfaces poses an additional problem of a rocky, hard surface, which does not easily lend itself to traditional anchoring methods. This program would look at the replacing the age-old technology of wooden and metal cylindrical stakes with advanced technology alternatives, while attempting to reduce the weight, bulk, and manpower requirements for anchoring shelters.

PHASE I: Investigate one or more methods for anchoring deployable structures and shelters, such as soil stabilization, reversible phase change polymers, advanced material selection, and novel designs. Evaluate concepts to assess feasibility and load carrying ability in a variety of soil types and conditions.

PHASE II: Further develop and improve anchoring system, fabricate prototypes, and demonstrate concept. Evaluate applicability for large area shelter or shelter complexes at high wind/snow loads and various soil types and conditions. Validate life cycle cost savings and feasibility of widespread field use, determine environmental impact of any chemical type soil stabilization system.

PHASE III: Commercial shelter manufacturers would be interested in these types of advances in anchoring, and for soil stabilization at outdoor public events and concerts, for many of the same reasons.

KEY WORDS: soil, ground, shelter, stabilization, anchoring

A01-198 TITLE: Distillation System for Recycling Greywater Generated by Field Feeding Operations

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: To develop a system that recycles greywater generated by the Food Sanitation Center (FSC) in field feeding operations. This system will become part of the Advanced Food Sanitation Center (AFSC) to reduce the volume of greywater that must be backhauled.

DESCRIPTION: Field feeding operations generate hundreds of gallons of greywater each day, which is typically stored in large sump tanks or bladders and later backhauled for treatment. This becomes a logistical and environmental burden. Storage generally fills quickly, and contracted waste removal services are expensive and can be difficult to coordinate with erratic greywater generation. This sometimes results in disposal of untreated greywater to the ground, which can pose health problems and harm the environment.

The FSC has three sinks, each filled with 20 gallons of water for washing, rinsing and sanitizing, in ascending order of purity and temperature. Depending on the size of the group being fed, two batches of water may be used for each meal (240 gallons per day total). Greywater produced typically has biological oxygen demand (BOD) levels in the range of 900-1100 mg/L, suspended solids 600-800 mg/L, oil and grease 200-400 mg/L, and pH levels between 6 and 9.

The greywater recycling system should be self-powered or have minimal electrical requirements, but can use a battlefield fuel (JP8, diesel) burner for a heat source. The system should be lightweight (147 lb or less), rugged, portable, high-efficiency (more than 25 lb water for 1 lb fuel burned), and cost-effective. The system should process greywater as it is produced during the sanitation cycle, continuously or in 20-gallon batches. The treated water should be sufficiently clean to reintroduce into the FSC sinks as a substitute for fresh potable water. It is envisioned that as the wash water is being processed, rinse and/or sanitizing water could take its place, with the treated water returned to the sanitizing sink. Because the objective is to minimize the amount of greywater backhauled, the amount of discharge should be small compared to the greywater processed (less than 10%).

Potential technologies for implementation include, but are not limited to, evaporation, flash distillation, membrane distillation, multi-effect distillation, and pervaporation. Novel heat-driven processes are encouraged.

PHASE I: Establish the basic operating concept through the design and development of a proof-of-principle prototype, demonstrate operation and reliability, and provide strategies to meet all described requirements with minimal risk. Characterize system effectiveness by testing with a standard greywater solution that reflects the greywater generated the field.

PHASE II: Refine the design to meet all requirements and fabricate a full-scale prototype system for in-house testing at the Natick Soldier Center to verify operational capability, durability, and efficiency. Provide user manuals and short term service to support the in-house testing of the equipment. Address manufacturability issues related to full-scale production for military and commercial utilization.

PHASE III: Restaurants, laundries, recreational vehicles, parks, and truck washing applications are all potential uses for this device in the commercial sector.

REFERENCES:
Army Field Manual No. 10-23 - Basic Doctrine for Army Field Feeding and Class I Operations Management.

KEY WORDS: Greywater, gray water, water treatment, sanitation, field feeding, distillation, filtration, recycling

A01-199 TITLE: Common Fuel Engines for Powered Parafoils and other Airborne Systems

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: Develop a 100-150 HP common fuel (JP8 or diesel) engine for unmanned powered parafoils and other airborne vehicle applications. Engines must be capable of being air dropped, cold started, and continuously operated at altitudes up to 20,000 feet MSL.

DESCRIPTION: Commercial engines for powered parafoils are fueled with gasoline. However, the availability of gasoline on the battlefield is restricted and presents undesired logistics concerns. A common fuel engine for a powered parafoil and other airborne vehicle applications would comply with DoD Directive 4140.25, DoD Management Policy for Energy Commodities and Related Services.

Engines for air dropped powered parafoils not only have different power and speed requirements than engines used in more conventional, fixed wing, unmanned aerial vehicles (UAVs), they also must be capable of starting cold and continuously operating at altitudes up to 20,000 ft., and withstanding canopy opening shocks. Significant development time and cost savings are expected since the intended application for this engine is a relatively inexpensive unmanned vehicle (for which fuselage drag is not a major concern) and not a general aviation product requiring FAR 33 engine certification.

PHASE I: This phase will focus on the enabling technology for and the research and development of a design for a common fuel engine (approximately 100-150 HP), for powered parafoils, that is capable of being air dropped, cold started, and continuously operated at altitudes up to 20,000 ft. mean sea level. Consideration to cost, weight, and the ability to function predictably in a wide range of environmental conditions is essential.

PHASE II: Upon successful completion of Phase I, at least one prototype engine will be built and fully characterized/tested for powered parafoil airdrop applications. Government furnished equipment (GFE) for the installation of an engine into a powered parafoil platform and airdrop test range support may be requested. A detailed design and life cycle cost analysis is desirable.

PHASE III: Recreational powered parafoils and ultralight aircraft are expected users of this technology. In addition, the development of high efficiency, common fueled, small engine technology would have a direct application to the commercial and military markets for power generation equipment, outboard engines, and all-terrain vehicles.

REFERENCES: none

KEY WORDS: engines, parafoil, fuel, airdrop

A01-200 TITLE: Precision Low Cost High Altitude Deployable Aerial Delivery Systems

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: To develop and demonstrate new concepts and methods of low cost systems for high altitude precision aerial delivery of heavy cargos and use in many DoD airdrop mission scenarios. Systems such as gliding clustered parachutes or large controllable round parachutes may be investigated but concepts are not limited to these two. Offerors should consider use of existing US Army airdrop components to the maximum extent possible. These concepts may also lead to the commercialization of the technologies for space/satellite reentry application and humanitarian missions. Concepts with potential of scaling to at least 10,000 pounds of delivered payload are desired.

DESCRIPTION: The US Army is actively pursuing advanced parachute and airdrop technologies to develop high altitude aircraft survivable precision airdrop systems. High altitude delivery significantly reduces aircraft vulnerability and precision airdrop provides rapid, precise delivery of payloads where they're needed. These systems will reduce drop zone sizes and load dispersion for quick airdrop mobility. Concepts should consider low cost as a critical parameter. Anticipated costs should be substantially less than the cost of equivalently sized guided parafoils, which have been investigated for precision airdrop applications, and have additional capabilities such as larger offset (larger drop zone) choices for a given release point. The Natick Soldier Center is currently pursuing affordable, low cost, precision cargo airdrop systems using ballistic or semi-ballistic flexible aerodynamic decelerators. Both control of single round, cross parachutes and clusters of round parachutes are being explored. The goal of the system scalable to deliver payloads up to at least a 10,000 lb load from up to a 25,000 ft MSL deployment altitude with a 50 to100-meter Circular Error Probable (CEP) on the drop zone. Gliding single parachute are and have been studied (References 1, 2, 3 and 4), and the guided single round parachute is currently being investigated (References 5 and 6) for precision airdrop. However, scaling to larger payload weights presents additional challenges and new cost effective low glide systems should be proposed. A desired glide ratio of at least 0.5, and preferably between 1.0 and 1.5, is desired. Offerors can anticipate that the transport aircraft will be equipped with a mission planning system that will provide target location and a relatively accurate (+/- 2 meters/sec and +/- 15degree) data dump of winds just prior to deployment from the aircraft. Innovative concepts and new methodology in using standard parachutes as part of the system for precision cargo delivery is recommended.

Guidance, navigation and control (GNC) software can be proposed or can be provided as Government furnished equipment (GFE) during the effort. Radio controlled prototypes are desired and GFE testing will be conducted if desired. Ultimate complete autonomous control and precision landing are desired. Currently, clusters of either Army G-11 (100-ft diameter) or G-12 (64-ft diameter) parachutes are used for cargo delivery but this study is not limited to these two standard Army cargo parachutes.

PHASE I: In this Phase, new innovative concepts and technologies/methodologies to develop a low cost controllable airdrop system for high altitude deployed applications is desired. Offerors may consider the use of computer simulations to analyze these new concepts and system performance. Wind tunnel testing can be conducted to study the aerodynamics of the system. Based on these results, a moderate sized system will be tested from a light aircraft to investigate its glide and control performance. It is desirable to design and potentially test at least a 2,200 and up to 5000lb system. Construction of a scaled system, and radio controlled airdrops from an aircraft to demonstrate performance, are desired.

PHASE II: In this Phase, the 2,200 or 5,000 lb system will be fully designed and fabricated. The system's inflation characteristics, glide ratio, turn performance and landing dynamics will be predicted, measured, and refined during this phase. Based on these test results, a scaled up 5,000-lb system should be considered, designed and if resources permit, built and tested. GNC software (by offeror and/or GFE) will be generated and coupled with a low cost control/actuator, to complete the system. The system will be airdropped and tested from a military transport aircraft, such as a C-130. System performance will be monitored, measured and demonstrated.

PHASE III: Currently there are strong interests in the private sector for a low cost, autonomous, precision airdrop system to recover rocket boosters of commercial satellites to earth when they are launched into space. The 5,000-lb system and a scaled up 10,000 system will be ideal for this dual use application. NASA desires accurate methods of reaching desired targets on planets. Humanitarian applications are numerous. Resupply to remote areas and/or delivery of shelters, weather stations and prepositioned resources are potential commercial applications.

REFERENCES:

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2) Menard, G. L. C., Performance Investigation of Various Configurations of Personnel Maneuverable Parachute Canopy Assemblies, Technical Report No. 5-71, US Naval Aerospace Recovery Facility, El Centro, CA, February 1972. (Available from the Defense Technical Information Center, Ft. Belvoir, VA, Report No. AD 893225.)

3) Steele, J. L., Evaluation of Steerable Parachutes; Final Report, Report No. D 023/JLS:mrt, US Marines Corps Development and Education Command, Quantico, VA, January 1973. (Available from the Defense Technical Information Center, Ft. Belvoir, VA, Report No. AD 907186.)

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5) Brown, G. et al., The Affordable Guided Airdrop System (AGAS), Proceedings of the 15th CEAS/AIAA Aerodynamic Decelerator Systems Technology Conference, pp.316-325, Toulouse, France, 8-11, June, 1999.

6) Dellicker, S., et al., Low Cost Parachute Guidance, Navigation, and Control, Proceedings of the 15th CEAS/AIAA Aerodynamic Decelerator Systems Technology Conference, pp. 51-65, Toulouse, France, 8-11, June, 1999.

KEY WORDS: Precision airdrop, gliding clustered parachutes, cargo parachute system, high-altitude airdrop, autonomous airdrop system, and guidance, navigation and control.

A01-201 TITLE: Isothermal Blanket for Safely Tempering Frozen Food

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM:

OBJECTIVE: Develop technology for a blanket that will safely temper frozen meat for field food service.

DESCRIPTION: Cases of frozen poultry, beef, and pork are distributed from refrigerated containers at ration break points to food service personnel that have no means for safely thawing (tempering) the meat. The meat is reportedly left in a tent over night to thaw in violation of the basic doctrine for field feeding, FM 10-23, which requires tempering to be performed in a 45 degree F refrigerator. This practice can lead to food born illness from salmonella, e-coli, staphylococcus, and other related

bacteria/microbes. Although it is not practical to maintain refrigerators with 24 hour generator support, some means is required to ensure food safety. Accordingly, there is a need for a lightweight cover or blanket that can be placed over a pallet of frozen meat, that can be used to maintain a uniform temperature no greater than 45 degrees F. This blanket should be able to temper the frozen meat over an 18-hr period at an ambient temperature ranging from 50 degrees F to 120 degrees F. Rationale for the 18-hr duration is that a pallet of rations typically will be taken out the night prior to serving. Assuming the meat is taken out of refrigerated storage at 1800 hours, and will be used in the preparation process at noon the following day, an 18-hr period would be required. The blanket can be a composite or lamination of materials that serve to insulate and distribute heat. Phase change materials and vents that respond to temperature could also be used for regulation. It is desired that the blanket be non-powered, but approaches that utilize small amounts of battery or solar power shall be considered. The blanket will be used in or in close proximity to a field kitchen, thus providing an immediate source of heat if required to operate the blanket. For design purposes, frozen chicken is issued at a rate of 84 pounds per 100 soldiers. The standard field kitchen, the Mobile Kitchen Trailer, feeds 250 to 300 soldiers. Therefore, the blanket should be capable of thawing about 250 pounds of chicken. A typical box of chicken, for the Unitized Group Ration-A (UGR-A), is 18.2 inches (length) by 12.25 inches (width) by 4.7 inches (height) and weights around 17.75 pounds. These boxes will be spaced, upon thawing process initiation, to allow for uniform tempering. The blanket shall be capable of covering the typical pallet dimensions of 48" (length) by 40" (width) by a variable height (up to a maximum of 46 inches as UGR-A's vary depending on food type). For the chicken, the total pallet height will be 20 inches.

PHASE I: Identify the most promising materials and configuration for the blanket. Develop and demonstrate a proof of principle prototype. The blanket shall perform automatically with minimal monitoring. Identify aspects in need of improvement and report strategies for meeting requirements in Phase II.

PHASE II: A prototype blanket shall be constructed and tested regarding thermal performance, conductivity and durability.

PHASE III: This blanket technology could also be utilized in the field of emergency medicine for treating hypothermic victims. Since the aim of this function is to maximize solar gain, the exterior of the blanket shall be constructed of a dark waterproof material. It may be possible to have a reversible external shell to alter the function depending upon the desired use. Another application would be for providing an emergency back-up to a refrigeration system undergoing repair in the field. Regarding this, one of the most extensive repairs is the replacement of the compressor, which can require up to 12 hours. For this scenario, the blanket should be able to keep products frozen (32 degrees F) for at least 14 hours in an ambient temperature of 120 degrees F

REFERENCES:
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2) Darsch, Gerald A., Operational Rations of the Department of Defense, Natick PAM 30-25, 4th Edition

3) Sparks, R.E. "Microencapsulation", Kirk-Othmer Encyclopedia of Chemical Technology, Vol. 15, 3rd Edition, John Wiley and Son, Inc, 1981

KEYWORDS: isothermal, durable, equilibrate, thermal blanket, tempering, R-value, solar gain

A01-202 TITLE: Non-stick Coating for Field Cookware

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Soldier Support

OBJECTIVE: To significantly reduce the weight, cube, and cost of food sanitation while concurrently reducing the gray water produced through the novel use of non-stick coating.

DESCRIPTION: Washing cookware in field kitchens currently requires 3 sinks each filled with 20 gallons of hot water for washing, rinsing, and sanitizing. This sanitation cycle uses about 240 gallons water per day, which must be treated or back-hauled for disposal. The cookware is made from 6061 uncoated aluminum. Adding a non-stick coating to the cookware will make it much easier to remove the food waste, thereby reducing the amount of water needed to clean the cookware. The coating will also serve a dual use by protecting the aluminum cookware from the typical corrosion and pitting that now occurs thus extending the life-cycle cost of the cookware. Standard coatings for pots and pans are not durable enough for field use. The coatings flake or peel, making the pan hard to clean and exposing the bare aluminum to food and corrosives. A more durable coating is required for field feeding. The coating should have a minimum Knoop hardness value of 600 and a Taber abrasion value of less than 1 mg lost when using a No. 17 wheel for 1000 cycles and a 1000-gram weight. The static and kinetic friction

coefficients should be less than 0.17 as per ASTM D1894-95 (run against stainless steel). The coating should be able to withstand temperatures between -80°F and +550°F and a salt spray of 1000 hours as per ASTM B117-97. It should not react with acids, bases, or solvents and be non-toxic and inert to human consumption. The coating must be no thicker than 2.00 x 10-3 inches thick so as not to interfere with certain tolerances of the pan. It must also be FDA approved for food contact.

PHASE I: Develop a coating that will withstand the rigors of field fielding. Demonstrate the coating's viability through ASTM standard tests as well as several mock field-feeding exercises.

PHASE II: Develop methods for applying the coating in the field. Develop a portable applicator that will safely and effectively apply the coating to Army issue pots and pans using a minimal footprint.

PHASE III: The coating can be marketed in the home cookware sector as an improvement over current coatings. It can also be marketed in the industrial sector as a high-strength, durable non-stick coating for food processing, film production, ball bearings, or any other process that would benefit from non-stick surfaces. Mobile applicator with a minimal footprint reduces overhead.

REFERENCES:
1) Army Field Manual, FM 21-10-1, "Unit Field Sanitation Team "
2) Army Technical Bulletin, TB-MED-530, "Occupational and Environmental Health Food Service Sanitation"
3) Army Field Manual, FM 10-23, "Basic Doctrine of Army Field Feeding and Class I Operations Management"

KEY WORDS: Coating, non-stick, water reduction, field feeding

A01-203 TITLE: Weapon Firing Algorithm for Simulated Individual Combatants

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an algorithm to predict weapon-firing behavior of a simulated individual combatant following a target detection event. Decisions related to weapon firing will take into account personal goals, goals imposed by others, and terrain features and other attributes of potential targets and target locations.

DESCRIPTION: The Individual and Unit Simulation System (IUSS) simulates combat scenarios involving individual combatants (ICs) and small units (SUs) made up of ICs. The IUSS is used to assess warfighter systems. Currently, simulated IC and SU behavior is highly scripted. To better assess the effects of warfighter systems on simulated IC and SU performance, the IUSS is now moving toward a more intelligent simulated IC that is able to react to and affect events in the simulation.

A key aspect of simulated IC intelligence is the capability of the simulated IC to respond to a detection event. Expected responses include picking which potential target (if there are multiple potential targets) to focus on, identifying the potential target (e.g., friend vs. foe) and, if foe, selecting a weapon/projectile system, mode of fire, aiming point, number of rounds to use, etc. These decisions will be based on the goals of the IC as well as the goals of the unit (e.g., rules of engagement). These decisions also will be based on attributes of the potential target and the potential target's location, as well as certainties about these attributes. This decision-making/behavior process is dynamic, evolving over time as information is received and processed.

PHASE I: Objectives of the Phase I research are to:

1. Assess decision-making algorithms currently being utilized in software or in other applications and their potential for military application.
2. Obtain data related to combat weapon firing at a depth sufficient to identify important variables and the most appropriate ways to represent decisions and behaviors (i.e., algorithm inputs and outputs). If existing data are insufficient, the developer is expected to obtain new data through appropriate mechanisms such as expert interviews.
3. Coordinate with the Warrior Systems Modeling Technology STO Team and the IUSS Development Team in identifying algorithm input and output variables.
4. Evaluate potential algorithmic methods and identify the most promising method for achieving project objectives.
5. Conduct feasibility assessment of proposed solution.
6. Identify data requirements necessary to populate potential algorithmic methods.

Deliverables will include a detailed report of all findings including data, analyses, and evaluations from the Phase I effort. The report will also recommend, with supporting evidence, candidate decision-making algorithms that are worthy of pursuit and a proposed way forward for algorithm development in Phase II.

PHASE II: The Phase II objectives will include algorithm development, algorithm validation, and a prototype algorithm demonstration. The algorithm must include decisions made by the simulated IC in response to a potential target detection event, up to and including the firing of the selected weapon/projectile system. The system must also be dynamic; the decision making process should evolve over time and incorporate new information as it is received. The developer will coordinate efforts with the IUSS development team to ensure compatibility with IUSS representations of terrain, environment, command and control, opposing forces, ICs and SUs. The simulated IC weapon-firing algorithm must be validated for both open field and urban terrain. The algorithm developer is responsible for obtaining existing data that may be available for this effort. The developer is not expected to collect new data during Phase II.

PHASE III: With little modification, the algorithm developed as part of this effort could be applied to other war gaming and law enforcement simulations. Technological advances developed during the conduct of this effort could be used to benefit industries utilizing decision-making algorithms, simulated entities and autonomous mechanical systems.

REFERENCES:
Harper, Karen A., Stephen S. Ho, and Greg L. Zacharias. Intelligent Hostile Urban Threat (IHUT) Entities for Military Operations on Urbanized Terrain. Prepared for Naval Surface Warfare Center, Indianhead, MD, Report Number R99091. Charles River Analytics Inc., 725 Concord Avenue , Cambridge, MA 02138. September 24, 1999. (Call 1-617-491-3474 for reference).

KEYWORDS: Simulation, intelligent agent, individual combatant, weapon firing, decision making, algorithm, war gaming.

A01-204 TITLE: Enhanced Lethality for Army Directed Energy Weapon Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop enabling technologies in high energy, solid-state lasers which will enhance their field utility and deployability for the U.S. Army. High energy laser weapon systems have the potential to provide a) Precision Engagement through speed-of-light, high probability of kill, precise aim point, and multiple hits on target, b) Full Dimensional Protection through protection of early entry forces, engagement of rockets, artillery, and mortars, including accent phase, and c) Focused Logistics through low cost-per-kill and decreased logistics burden. An additional potential operational mission is the standoff destruction of unexploded ordnance and surface-laid landmines utilizing highly mobile laser platforms. To fully realize these potential benefits, key enabling technological advancements are needed.

DESCRIPTION: Directed energy weapon systems must be rapidly deployable, rugged, reliable, efficient, maintainable and sustainable. Specific interest areas for improvements in the application of solid-state lasers (SSL's) include: a) improvements in diode reliability for diode pumped solid-state lasers, b) application of adaptive optics to tactical Army needs with particular interest in new concepts and designs in wavefront sensor packaging to dramatically reduce dimensions and cost, c) solid-state laser gain module materials improved Nd:YAG or alternatives such as Yb:YAG or Er:YAG materials, d) new concepts or designs which extend the upper average power range of diode pumped SSL's, e) new concepts or designs for fiber optic laser systems such as low cost-per-watt, high power diodes with improved output coupling to the fiber, f) diode and system designs which can sustain storage in field (e.g. subfreezing) environments, g) improvements which result in maintaining high average output power over an extended system life, and h) other novel concepts and designs which improve efficiency, beam quality or Strehl ratio, system deployability, fieldability, or reliability.

PHASE I: Analyze and evaluate new concepts or designs and conduct proof-of-principle experimentation.

PHASE II: Design, fabricate, and test prototype-scale device or components. Conduct parametric assessments. Demonstrate improvements of new concept/design over existing technologies.

PHASE III: In addition to direct applicability to Army Directed Energy programs, enhancements to the performance and reliability of solid-state lasers with a range of average-power would have commercial applicability in industrial operations, materials processing, medical/surgical use, lithography, imaging, remote sensing, and communications.

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KEYWORDS: Lasers, directed energy, solid-state, diode, adaptive optics

A01-205 TITLE: <u>Development of Advanced Algorithms to Mitigate Radio Frequency Interference in Missile Defense BMC4I Electronics</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: Program Executive Office- Air & Missile Defense

OBJECTIVE: Identify, develop, and demonstrate advanced algorithms to protect missile defense Battle Management Command, Control, Communications, Computers and Intelligence (BMC4I) electronic systems from hostile or co-site radio frequency (RF) and electromagnetic (EM) interference.

DESCRIPTION: The incorporation of modern microelectronics into military electronic systems lowers the threshold for damage from RF and EM sources. Many effects of RF and EM radiation can be mitigated through limiters and shielding. However, no single protection method will protect against all electromagnetic interference. One area of protection that has been overlooked is the use of algorithms both to prevent EM interference from affecting the electronics and to correct the effects of EMI without having to manually intervene.

Out of band and/or very short pulse RF radiation can enter electronics, even if limiters and shields are in place. This radiation can cause electronics to enter into undesired states and cause the circuit to become unstable, and in some cases, chaotic. The speed with which technologies like limiters can respond will always be limited by materials properties. External shields will protect against a number of back-door radiation sources, but cooling fans and cable feeds provide entry paths for radiation. This leads to a need for a new method to protect critical electronics. A potential starting place for this algorithm development is to apply control theory to the problem. A number of state-of-the-art control methodologies could be investigated to mitigate the effects of EMI. These methodologies include, but are not limited to, neural networks and fuzzy logic, optimal control, and sliding mode control.

Any approach that is conceived must be taken beyond the theoretical level. Insertion methods into new and existing BMC4I hardware must be considered. Adaptive monitoring and control mechanisms can be applied using secondary circuits or other innovative use of existing on-board resources. Any technique proposed must be applicable to Commercial Off The Shelf (COTS) electronics. Because of the potential need to incorporate these algorithms into existing systems, the technology insertion technique must applicable to a wide variety of electronic systems.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of algorithm-based techniques to protect military BMC4I electronics from external radio frequency emissions.

PHASE II: Optimize algorithms and develop prototype protection devices. Conduct hardware tests to evaluate the performance of the protection devices and protected equipment in challenging RF environments. Prepare detailed plans to implement demonstrated capabilities on critical military and commercial applications.

PHASE III: Dual applications exist for RF mitigation technologies with the commercial electronics industry. The RF environment that commercial radars, communications equipment, and other electronics are exposed to is becoming increasingly severe. The technologies developed through this research program will provide protection of both military and commercial electronics from both accidental and deliberate threats.

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2) "Generation of High-Power Ultra-short Microwave Pulses and Their Effect on Electronic Devices, " S. Bludov et al, Plasma Physics Reports, Vol. 20, No. 8, 1994, pp.643-647.
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KEYWORDS: Control Algorithms, Radio Frequency Mitigation, Electromagnetic Interference, Optimal Control, Neural Networks, Sliding Mode Control

A01-206 TITLE: Enhanced Munitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO, Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop enabling technologies in pulse power, ultrawideband systems, and/or high power microwave devices which could be applied to provide enhanced medium caliber munitions (40-mm to 155-mm) with a directed energy capability as well as to commercial uses such as water purification and enhanced sensor devices.

DESCRIPTION: The radius of damage and the destructive power of conventional munitions is limited to that of the blast and fragments. The military goals of this effort are to extend the lethal range of munitions, increase the scope of the target set, and enhance destruction capability. A directed energy component, such as high power microwave or ultra-wideband signals can attack sensitive electronics and may have longer lethal ranges than blast waves and fragments. The commercial goal of this effort is to provide enabling technologies that can advance pulse power and ultra-wideband applications such as water purification, antenna technology, nondestructive testing and sensing. As the requirements for pulsed power systems with higher power output from smaller packages increases in the commercial market, further research and development is required.

PHASE I: Identify potential technologies and analyze, design, and conduct proof-of-principle demonstrations to 1) verify that the output is predictable and is consistent with predictions and 2) assess performance which may include evaluating the effects on various targets.

PHASE II: Design, build, and test enhanced prototype munitions and/or critical components and verify their capabilities under field conditions. Assess scale-up factors. Design production process for mass production.

PHASE III: The nonexplosive pulsed power technologies developed under this effort have numerous commercial applications including water purification units, nondestructive testing, magnetic resonance imaging, and lightning simulators. This technology is also being considered for use in millimeter wave seekers. The explosive pulsed power technologies also have commercial and R&D applications including prime energy sources for the National Ignition Facility, basic research in ultra high magnetic fields and their affects on materials, and oil and mineral exploration. This technology has also been considered for a remote sensing of land mines. The antenna technologies could lead to the creation of compact, lightweight collapsible ultra wideband antennas, surface mounted 2D ultra wideband fractal antennas, plasma antennas, and high power antennas for secure communications, long range communications, and satellite communications.

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KEYWORDS: Munitions, Pulsed Power, Marx Generators, Magnetocumulative Generators, Magnetic Flux Generators, High Power Microwaves, Ultra Wideband.

A01-207 TITLE: Aggregation of Single Integrated Space Picture (SISP)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM SHORAD

OBJECTIVE: Aggregate disparate sources of space object data into a metalanguage (for example, Extensible Markup Language) and prototype a platform independent single integrated space picture for display.

DESCRIPTION: The Army requires the capability to provide a single integrated space picture of all space objects that are overhead in any theater of operation. The sources of this data use various formats that will require translation during the aggregation process. The data is generated by various sources with disparate, often incompatible, characteristics such as quality ratings and object specifications (radar, IR, visible). For example, the metalanguage elements may include and integrate in-theater radar returns and optical measurements intended to supplement the accuracy and timeliness of ephemeris data. A prototype SISP picture or display will provide, as a minimum, fast-forward/reverse time displacement, drill down data menus, multiple views, and near optimal use of available display/operation characteristics to browse information in an intuitive and natural manner. This metalanguage-formatted information must be designed to enable a broad range of applications that support military Battle Management systems such as commander displays, and automated processes such as weapon systems.

PHASE I: Provide a prototype aggregate metalanguage data set and schema from open literature ephemeris and notional real-time sensor data. Present this aggregate data on an inexpensive commercial display system.

PHASE II: Extend the products from Phase I to integrate atmospheric data (weather, clarity, environment, etc.). Further enhance the display browser to include useful options discovered in Phase I. Show satellite coverage areas on ground map based on the information contained in the metalanguage data set and user preferences. Demonstrate that the quality of the aggregated data is superior to constituent individual source data.

PHASE III: Commercial and military groups are interested in the precise location of space objects, such as various military groups (intelligence, communications, space control, missile defense), astronomers, NASA, air-traffic controllers, commercial satellite launch companies, educational institutions, navigational companies, or others that use/leverage space-based satellites.

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7) http://celestrak.com/NORAD/elements/

KEYWORDS:
Space Surveillance Network, Satellites, Space Objects, Sensor Fusion,
Sensor Correlation, Track Correlation, Integrated Space Picture Aggregation,
XML, Metalanguage, Ephemeris data

A01-208 TITLE: Scaleable Process Technology for Nanostructured Materials

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO-Air & Missile Defense

OBJECTIVE: The objective of this effort is to develop leap-ahead technologies in nanophase or nanostructured materials and/or the processes used to produce them. Emphasis should be placed on structural materials whose nanoscale grain structure provides property enhancement such as very high strength at operational temperatures, ultra-high specific stiffness, or novel characteristics such as multifunctionality (e.g. structural thermite intermetallics), or self- healing ability. Cost-effective fabrication process technologies that are scaleable to production are of particular interest.

DESCRIPTION
Substantial progress has been made over the past decade in nanotechnology and nanostructured materials. Laboratory discoveries offer the promise of significant increases in mechanical, electrical and other properties. Relatively limited progress has been made in developing large scale manufacturing capability and transitioning these discoveries to real-world applications. Missile Defense systems require a host of high performance materials in hardware to detect, discriminate, intercept and destroy hostile offensive systems. Therefore, substantial latitude is left to interested firms in proposing advanced material concepts that could be applied to meet these needs. Promising technology areas include, but are not limited to, thermal or kinetic spray forming processes which produce nanoscale grain structure, rapid solidification with in-situ nucleation of nanocrystalline phases, and high rate processes for producing well-characterized nanoparticles (fullerines, nanotubes). Proposed efforts should seek to provide revolutionary performance improvements based on nanostructured materials with particular interest in structural material systems. Such enabling materials and process technologies would be readily adaptable to commercial applications, providing for dual-use applicability.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to include materials fabrication and characterization.

PHASE II: Demonstrate feasibility of engineering scale-up of proposed process; identify and address technological hurdles, and characterize the performance of novel materials. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The availability of a cost-effective process to produce high performance structural materials for missile defense applications, e.g. interceptors, could have a critical impact on fielding an effective system. Improving system performance (velocity, range, lethality) with equivalent or lower costs could be the result of successful development. Equally important is the transferability of such process technology to highly cost-critical commercial applications in aerospace, sporting goods, automotive, and industrial uses.

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KEYWORDS: Nanostructured materials, nanomaterials, munitions, reactive metals, multifunctional materials, lethality

A01-209 TITLE: Solutions to the Encroachment of DoD Frequencies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Instrumentation, Targets, and Threat Simulation

OBJECTIVE: The objective of this SBIR is to address the most critical issue threatening the DoD Test and Training centers: sufficient Radio Frequency (RF) bandwidth to test modern weapon systems. This SBIR would review the latest and emerging RF technologies and methodologies to allow the DoD test ranges to become more efficient with their present and future reduced approved spectrum.

DESCRIPTION: When most of the test ranges and training centers were established, they were set in relatively remote areas. As Army Systems became more complex, the complexity of the evaluation systems increased as well. Consequently, today we have many complimentary systems performing many functions on the ranges such as Time/Space Position Information (TSPI)/Global Positioning System (GPS), telemetry, vehicle status, situational awareness, audio, video, flightcontrol/termination, scoring, meteorology, range safety, test control and coordination, etc. All of these functions require transmitting digital data over RF links that have rather limited spectral bands. Because of the evolutionary nature of these systems, all of these systems were developed separately and require separate datalink/transceivers operating at different frequencies, none with modern state-of-the-art techniques to achieve high spectrum utilization/efficiency. Also, the range safety officers demand that all of these systems operate at different frequencies so that they will not interfere with each other, and they must have dual redundancy for all critical flight safety functions. This takes a huge amount of the total available bandwidth required to perform most any evaluation of a modern weapon system. The spectrum once only required by the military test and training community is now coveted by private industry for commercial use. Congress has sold off some of that spectrum and appears likely to sell off even more (there are some ranges now that can not fully transfer all data required for evaluation of the system under test). This SBIR's effort is intended to research and investigate what functions are required to evaluate modern weapon systems, what is technically feasible in combining range function, exploring new and future technologies for spectrum efficiency, and what functions could be suitable for other approaches that do not require RF solutions. A detailed spectral analysis of the future test and training ranges requirements could lead to the development of technology tools that more effectively test and evaluate the desired Objective Force characteristics. The legacy force systems would be able to more easily begin their transformation. Technology tools that allow the Army to test and train more effectively will greatly enhance the Army transformation from the Initial phase through the Objective Force phase. Following successful demonstration of this technology at the test and training centers, it could be incorporated into all areas of the DoD requiring radio frequency transmission of digital data. Loosing this spectrum is the single most critical element threatening the DoD test and training community and the evaluation of future weapon systems

PHASE I: Identifying all of the functions required at the test and training ranges for evaluating the weapon system of the Future Combat Systems and the Objective Force that require transmission of digital data and then determining which of those functions could be combined into multifunctional systems. Concurrently with this effort, explore all of the latest and emerging technologies to be more spectral efficient such as reduced sidelobe modulation, frequency and time diversity, error coding, antenna efficiency, ultra wideband, etc.

PHASE II: Apply Phase I knowledge and results and fabricate prototypes. Prototypes would be exercised at White Sands Missile Range or National Training Centers as appropriate to demonstrate the spectral efficiencies and increased capabilities provided by the technologies.

PHASE III: The results of the above technical demonstrations could be incorporated into all DoD digital transmissions, from prototype to production, and from T&E/training to Battle Labs, and the tactical /operational community in support of the Future Combat Systems and the Objective Force. This technology once matured, would have potential commercial applications, such as wireless internet, wireless local area network (LAN), millimeter-wave LANs, intelligent transport systems (ITS), cellular radio, and broadband wireless access.

OPERATING AND SUPPORT COST (OSCR) REDUCTIONS: The OSCR could be millions. The Test Cost Benefit Analysis (TCBA) for the Family of Interoperable Range System Transceiver (FIRST) project identified $270,000,000 in cost saving in the T&E community.

REFERENCES: (All of the following have resulted in spectrum loss from the DoD)

1) The Omnibus Budget Reconciliation Act of 1993

2) The Balanced Budget Act of 1997

3) Presidential Executive Order, 2 Oct 00, directing the Federal Communication Commission (FCC) to clear airwaves for the next generation of global wireless services.

KEYWORDS; Radio Frequency Components, Electronic Battlespace Environment, telecommunication, test ranges , training centers, TSPI, telemetry, situational awareness, spectral analysis, bandwidth, Future Combat Systems, Army Transformation

A01-210 TITLE: Synthetic Natural Environment (SNE) Development & Interoperability

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, COMBINED ARMS TACTICAL TRAINERS (CATT); PM STI

OBJECTIVE: To develop automated methods to generate the very large, complex synthetic natural environment (SNE) databases that are required for virtual simulation. The resulting databases must enable disparate simulation applications to operate in a distributed simulation in a manner that allows each application to meet its unique training and performance requirements while retaining a "fair fight" view of other participants.

DESCRIPTION: Modern virtual simulations require very large, highly detailed databases that contain a complete and correlated description of the synthetic natural environment (SNE). These SNE databases must include all the detail necessary to depict the simulated real world for visual and multi-spectral sensors, plus information required by computer reasoning applications such as computer generated forces, and the information required to generate electronic and paper maps. Most virtual simulations require that these synthetic natural environment databases closely match the corresponding real world area to allow mission preview and mission rehearsal. SNE databases must enable disparate simulation applications to operate in a distributed simulation in a manner that allows each application to meet its unique training and performance requirements while retaining an "interoperable" or "fair fight" depiction of other participants.

The Objective Force requires rapid generation of synthetic natural environment databases to support deployment planning and mission rehearsal. The size and complexity of SNE databases make production time-consuming and expensive. Research is required to develop methodology and algorithms to convert source data to a common simulation format such as SEDRIS. Research is required to develop tools and techniques to automate the generation of the full range of synthetic natural environment database products for the environment data model (EDM) and subordinated correlated databases such as visual, sensor, computer generated forces, electronic and paper maps. The resulting products will significantly reduce the cost and schedule to produce new SNE and maintain existing SNE. This research will extend the effective utilization of modern source materials such as multi-spectral satellite imagery and advanced commercial geographical information system (GIS) products. The resulting processes and tools will support the need for rapid generation of SNE required to support "mission preview" and "mission rehearsal" for the rapid deployment mission of the Interim and Objective Transformed Force. The resulting products will provide similar reductions to the cost of commercial simulation databases.

Simulations developed for the Objective Force will be required to interoperate with existing simulation applications. Research is required to develop methodology and criteria to enable and measure the level of "correlation" or "degree of interoperability" allowed by a particular set of synthetic environments for disparate simulations. The resulting products will significantly reduce the cost and schedule to utilize a common SNE among interoperating simulation platforms. The resulting processes and tools will support utilization of existing SNE & interoperation with existing simulators for the new simulators that will be required to support the Interim and Objective Transformed Force.

Improved SNE development tools and process resulting from this research will provide corresponding advantages to the commercial simulation business, and burgeoning entertainment market.

PHASE I: Investigate automatic synthetic natural environment generation and testing technologies available against the specialized requirements of virtual simulation to reconcile source data conflicts, and produce the variety of correlated databases necessary to represent the synthetic natural environment for all the virtual simulation elements. Investigate database correlation technologies available against highly specialized virtual simulation requirements. Examine approaches, algorithms, and methodologies to test correlation among related databases.

PHASE II: Apply prototype database generation and testing technologies to generate new and modified synthetic natural environment for a modern, complex military simulation application (rotary wing or ground vehicle distributed simulation). Apply prototype database correlation technologies on a modern, complex military simulation application (rotary wing or ground vehicle distributed simulation).

PHASE III: Broaden the application to the generation of the full range of commercial and military virtual simulation synthetic natural environment databases.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Synthetic natural environments for current military virtual simulation cost from $200,000 to $5,000,000. Automated tools and methodologies should reduce the cost to generate and modify virtual simulation databases by 30 to 70%.

REFERENCES:

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2) Aviation Interoperability with the Close Combat Tactical Trainer, by Jesse Liu, Angel Rodriguez, Jeffrey Abbot, Image 2000 Proceedings.
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4) http://www.SEDRIS.org

KEYWORDS: simulation, synthetic natural environment (SNE)

A01-211 TITLE: Modeling and Simulation of Force Projection and Logistics for the Objective Force

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, ONE SEMI-AUTOMATED FORCES (OneSAF)

OBJECTIVE: To effectively train and assess the Army's Objective Force from an operationally driven view, by inserting logistics and distribution effects into combat simulations. The Army's Synthetic Environment does not provide sufficient logistics fidelity to realistically represent the effects of logistics and deployment under simulated combat.

DESCRIPTION: There are three main goals to achieve in support of the objective force and they are: Provide effective logistics effects for objective force mission rehearsal and training; Create the capability to achieve operationally driven shooter to production connectivity for multilevel training, mission rehearsal and assessment; and provide the granularity required to efficiently train and assess logistics fidelity at different levels of command. The focus of these efforts will be on an Army objective force operationally driven sustainment and deployment view. To achieve this flexible tools are required to insert sustainment and deployabilty capabilities of new and emerging technologies into operational simulations such as the OneSAF Testbed (OTB), Warsim and JSIMS. What this is anticipated to require are tools that will insert composable deployabily (inter- and intra-theater), tools that address sustainment considerations and behaviors, and tools that will provide logistics and deployment context information between heterogeneous simulations. These tools should be capable of flexibly modeling new and emerging technologies and the behaviors dictating their use.

PHASE I: Provide a functional analysis of the proposed system. Define, document and justify what the system is intended to do and how this will be achieved. The anticipated output should be a comprehensive systems description.

PHASE II: Build and demonstrate prototype deployment tool, or prototype sustainment tool, or logistics context tool through the FORCEPLAD ATD with Future Combat System (FCS) concept systems.

PHASE III: Provide a means to accurately assess, train and conduct realistic objective force mission rehearsal through the flexible insertion of sustainment and deployment capabilities and behaviors into operational simulations. Variations of this technology could be applied to civilian disaster relief training and decision making systems. This technology could provide a commercial production development tool a means to more efficiently determine production strategies.

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KEYWORDS: Sustainment, Deployment and Logistics.

A01-212 TITLE: Simulation Toolkit for Multiple Forces and Sides

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Warfighters Simulation (WARSIM)

OBJECTIVE: To develop a simulation toolkit for multiple forces and sides that will extend constructive simulation force representation capabilities.

DESCRIPTION: Constructive simulations do not currently possess the ability to represent multiple forces and sides with the flexibility required for today's threat and coalition forces. For example, the threat may combine a traditional Soviet weapons system within a U.S. task force structure. Coalition forces may combine international forces with various levels of training, skills and equipment. This effort proposes to develop a toolkit product that extends the ability of constructive simulations to represent multiple forces and sides.

The toolkit will provide an interface that will allow a scenario developer to select and combine various tactics, techniques and procedures (TTPs) with task organizations and weapons platforms. The developer will be able to use the toolkit to extend the capabilities of a host constructive simulation. It is expected that the number of combinations will only be limited by the availability within the selected host simulation. The toolkit will facilitate the combination of factors, adjudicate the combinations, perform any aggregation required, and augment behavioral logic. The toolkit should be developed such that it will operate in conjunction with or could be easily integrated directly into the host simulation.

The research and development of the multiple foWarfighters Simulaiton (WARSIM) program would use the technology to fulfill WARSIM's multiple sides requirements. This effort directly applies to Objective Force Technology area "Advanced Simulation." WARSIM provides intelligent computer generated forces simulation technologies for division, corps and echelon above corps and ties into JSIMS for joint level computer generated forces. This technology would directly improve the ability to represent multiple sides in computer generated forces, not only for WARSIM but many other simulations.

PHASE I: Develop a tookit design that addresses the WARSIM requirements for the representation of sides, the alignment of sides into forces, and dynamic relationships between forces and sides.

PHASE II: Develop the toolkit product. Demonstrate with the WARSIM constructive model. Experiment and test with a realistic scenario.

PHASE III: Application to all DoD constructive simulations, including the Joint Simulation Systems (JSIMS) domain agents, One Semi-Automated Forces (OneSAF), and Joint Semi-Automated Forces (JSAF). Could be utilized for training and analysis of Military Operations Other Than War (MOOTW). Application to commercial game developers and the entertainment industry.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Reduction in labor for encoding required to provide simulations capable of multiple sides and forces capability. This technology will significantly reduce the technical risks, costs and time associated with Computer Generated Forces (CGF) development.

REFERENCES:
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2) OneSAF ORD, http://www.onesaf.org/public1saf.html

KEYWORDS: Computer Generated Forces (CGF), behavior representation, multiple sides, simulation

A01-213 TITLE: Virtual Environments for Medical Simulation

TECHNOLOGY AREAS: Information Systems, Biomedical

ACQUISITION PROGRAM: Medical Research and Materiel Command

OBJECTIVE: There is a need for realistic casualty generation and treatment of simulated virtual casualties for the military clinician. Current casualty generation methods are not captivating and do not set the mood for intense training situations that may be encountered. Current virtual simulation efforts have looked at keyboard entry and manipulation. This effort would explore connecting a commercial video game that generates casualties to an existing military medical simulation system or simulator. This would facilitate passing a casualty from the video game to the medical simulation, where treatment could be done on the commercial video game victim. As far as virtual casualty treatment, PC options to keyboard entry such as touch screen patient manipulation, haptic interface with a three dimensional view of the patient, and other new, innovative, and realistic approaches to the challenge of treating a virtual patient should be explored.

DESCRIPTION: Many of the commercially available video games do an extremely good job of setting the stage and generating anxiety for the players of the game. Furthermore, many commercial games offer very graphically intense casualties that are not available in the traditional warfighter simulations. There are also military medical simulation capabilities that offer good clinical capabilities, but lack the intensity that would normally be present when treating military casualties. The goal of this SBIR would be to provide an enhanced training tool for the military medical community that places the clinician in the intense, visually stimulated environment, prior to actually treating the patient. To accomplish this a physiological meaningful casualty or mapping must occur from the commercial video game. In other words the video game casualty would need to have some type of indications about what might be going on with the casualty. These indicators may include type of weapon fired, time since victim was fired on, condition of victim before he was fired on, heart rate, environmental conditions, etc. These victim(s) would then be mapped to existing military medical simulation capabilities using a DoD approved open systems architecture. The second piece of this SBIR effort would be an initial research and development effort to explore technologies that offer promise for the challenge of realistic treatment of the virtual patient. The effort will first involve looking at existing military and commercial virtual patient simulations. Attention should be given to how the trainee would manipulate the patient and the equipment required to treat the patient. The objective of the virtual treatment is to provide a mechanism for realistic and effective training for the military clinician. A variety of clinical conditions should be explored, including airway management, amputations, allergic reactions, and possible chemical and biological type injuries. Attention should be given to clinical accuracy in treatment methodologies. or mapping must occur from the "casualty generator".

PHASE I: Conduct feasibility studies exploring:
-Appropriate commercial video game systems and military simulation capabilities that would allow the generation of clinically meaningful casualties in the video game, transferring the patient to a military medical simulation, possibly triaging the patients, and then treatment of the patient. Some of the initial mapping of video game casualties to military medical simulation casualties would be done in this phase.
-Technologies that offer promise for the virtual treatment of patients. In addition to recommending a method for treating virtual patients, this study should address specific clinical conditions that will be examined.

PHASE II: Develop a prototype that connects a video game and an existing military medical simulation system by passing meaningful casualties to the medical simulation, possibly conducting triage of multiple patients, treating the casualties, and possibly sending them back to "duty" in the video game. DoD approved, open system architecture should be considered for the communication infrastructure. Based on the research in Phase I, develop a prototype that allows for realistic and meaningful interaction with a virtual patient in a PC environment.

PHASE III: Research and demonstrate the application of these prototypes to local EMT's, civilian hospitals and medical training establishments, etc.

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2) Rajput, S. and Petty, M. D. (1999). "Combat Trauma Patient Simulation Phase 2 System Overview", Proceedings of the Spring 1999 Simulation Interoperability Workshop, Orlando FL, March 14-19 1999, pp. 285-292.
3) Pettitt, M. Beth H. and John J. Anton. "Military Based User Assessments
For Medical Simulation", Proceedings of the I/ITSEC 2000, Orlando, FL, November 27 - December 1, 2000.
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5) Wood, D. D. and Petty, M. D. (1999). "HLA Gateway 1999", Proceedings of the Spring 1999 Simulation Interoperability Workshop, Orlando FL, March 14-19 1999, pp. 302-307.
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9) Delta Force II by Nova Logic, www.nova.logic.com/games/deltaforce2.
10) SWAT 3 by Sierra Studios, www.sierrastudios.com
11) SPEC OPS II: Green Berets by Ripcord Games, www.ripcordgames.com
12) Research Triangle Institute, the STATCareTM Trauma Patient Simulator. http://www.rti.org/vr/w/vmetsum.cfm.
13) HT Medical Systems, Endoscopic Surgical Simulator, www.ht.com.
14) Center for Innovative Minimally Invasive Therapy (CIMIT), http://www.cimit.org/main/research/atts.

KEYWORDS: virtual patient, medical, simulation, video games
Rainbow 6, Rogue Spear by Red Storm Entertainment, www.redstorm.com/roguespear

A01-214 TITLE: Advanced Display Technology for Virtual Simulation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM COMBINED ARMS TACTICAL TRAINERS (CATT); PM STI

OBJECTIVE: To develop technologies necessary to cost-effectively adapt modern, high-volume, consumer display technology for use in military virtual simulation, particularly for simulation of low light levels and high motion rates.

DESCRIPTION: Display technology is exploding to meet consumer requirements, particularly in the form of flat panel displays for personal computing and high brightness projectors for front and rear screen projection for audience presentations. However, these technologies are not well suited to the special needs of military simulation, where many of the most critical operations are performed in low light levels (dusk, dawn, or night at various levels of lighting from direct and diffuse sources), and involve high speed movement of own-vehicle and targets. The light level of the most modern displays cannot be controlled with sufficient accuracy to provide for realistic simulation of low light conditions such as dusk, dawn, and moonlit nights where military operations are frequently conducted. Important parameters such as gamma are not well characterized for virtual simulation. Image smearing due to active pixel element latency in these new displays adversely affects simulation of high-speed apparent motion of own-vehicle and targets. The sensitivity of the digital processing of these new displays often produces distracting quantization artifacts and high susceptibility to electromagnetic noise. Quantization artifacts and noise are particularly problematic when these displays are interfaced to traditional computer image generation equipment. The digital to digital interface available for new computer image generators is not currently adapted for legacy image generation equipment. Utilization of this modern display technology will allow many benefits, including reduced acquisition cost, reduced support cost, flexible packaging, improved ruggedness and transportability, and ease of setup and alignment. Use of this technology will satisfy the current and continuing need for cost-effective modernization of legacy display systems. Use of this technology will specifically enhance our ability to provide deployable, rugged simulators to support operational deployments of the Interim and Objective Transformed Force.

PHASE I: Investigate technologies available against specialized virtual simulation requirements such as low light level visualization, high speed apparent motion, and cost. Develop methods and algorithms to cost effectively adapt high-volume, commercial display technologies to control contrast, brightness, and image latency.

PHASE II: Develop, integrate, and test the necessary customization of at least one class of modern, high, volume, commercial display technologies in a complex military simulation application (ground vehicle and aviation). Sample military simulation applications would include ground vehicle simulators such as, Close Combat Tactical Trainer (CCTT) or Advanced Gunnery Training System (AGTS) and aviation simulations such as, Aviation or Apache Combat Mission Simulator (CMS) that are referenced below.

PHASE III: Significant commercial sales potential exists for advanced virtual simulation display systems for commercial (civil aviation) and military simulation market. Adapted displays may also service other low light applications such as medical imaging.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Display systems for current military virtual simulation cost from \$200 to \$500,000 per channel. The underlying commercial display technology is often an order of magnitude less, due to economy of scale. The proposed system is a candidate for the "technology insertion through spares" program since a large number of military programs have display systems ending their supportable service life and the acquisition cost of the proposed display system compares with the operating and maintenance cost of current system.

REFERENCES:

1) How Modern Display Technology Has Affected the Training/Simulation Industry, by Angel Rodriguez, David Peters, 2000 SID Symposium for Information Display Digest
2) It May Be Gamma to You, But It's Greek to Me, by Maureen Stone, Todd Newman and Mark Callow, http://www.parc.xerox.com/red/members/stone/vrml-cfwg/gamma/default.html
3) Frequently Asked Questions About Color, by Charles Proynton, 12/30/99, http://www.inforamp.net/%7Epoynton/PDFs/ColorFAQ.pdf
4) Close Combat Tactical Trainer (CCTT) http://www.stricom.army.mil/STRICOM/PM-CATT/CCTT/
5) Advanced Gunnery Training System (AGTS) http://www.stricom.army.mil/PRODUCTS/AGTS/
6) Aviation Combined Arms Tactical Trainer (AVCATT) http://www.stricom.army.mil/STRICOM/PM-CATT/PM-ACTT/AVCATT/
7) Apache Combat Mission Simulator (CMS) http://www.stricom.army.mil/PRODUCTS/AH64/

KEYWORDS: simulation, display

A01-215 TITLE: Geometric Pairing

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM, INSTRUMENTATION, TARGETS AND THREAT SIMULATORS

OBJECTIVE: Develop Geometric Pairing Technology to support force-on-force testing and training.

DESCRIPTION: Geometric Pairing simulates the impact of a round fired on target by knowing the direction vector of the weapon on the firing platform at time of fire, time of trigger pull, munitions performance characteristics and geographic location of both the firing and target platforms. This capability offers the potential to fully instrument and evaluate all current and future US Army weapons systems, regardless of terrain restrictions. In additions it offers the potential further embed training into the vehicle and reduce the amount of hardware on weapon platforms to support training.

Current U.S. Army force-on-force testing and training incorporates the use of laser-based systems. Two examples of such systems are, Multiple Integrated Laser Engagement System (MILES) and the Mobile Automated Instrumentation Suite (MAIS) which are designed to support direct line-of-site engagements and have not been developed to simulate the effects of engaging targets with non-line-of-sight weaponry. With the continuing development of weapon systems designed to attack and defeat hidden targets, integration of these capabilities must be incorporated into both the testing and training communities to fully understand their impact on the battlefield. This capability can fully support Future Combat Systems and Objective Force requirements.

There are several technological approaches to Geometric Pairing. The two dominating technologies are Global Positioning System and Ultra Wide Band. The first, Global Positioning System (GPS) Technical Approaches, incorporates the use of differential corrections between a differential GPS station, located on a precisely surveyed reference point, and another GPS reported location. By comparing the reported location to the surveyed station, an error correction is determined and transmitted. The second approach, Ultra Wide-band (UWB) Technologies, utilizes low power, single-cycle pulses. UWB has demonstrated accuracy to within a few centimeters.

PHASE I: Develop a feasibility study to investigate Geometric Pairing Technology as a method for use in common instrumentation systems. Determine capabilities in supporting mounted and dismounted weapon systems. A major concern during this phase is achieving a sufficient degree of accuracy in the calculations to correctly register a "hit".

PHASE II: Apply results of phase I study to produce and deliver a prototype instrumentation system using Geometric Technology for dismounted troops and the non-line of site MK 19 40MM Machine Gun. Identify the full spectrum of weaponry for which the prototype could be applied.

PHASE III: This technology may be applied to a specific weaponry application identified in the phase II prototype. As an example, an application may be a vehicle configuration that would support Force XXI Battle Command Brigade and Below (FBCB2). Demonstrate the application using a surrogate vehicle.

The technologies developed under Geometric Pairing have extensive dual use potentials. For military applications, Geometric Pairing enhances both the testing and training communities by incorporating accurate representations for direct and indirect-fire weapons with the potential for less hardware required to support those simulations. Coupled with MAIS' capability to emulate current and existing weapon systems, accurate evaluation of developing systems and formations (i.e. Future Combat Systems, Interim Combat Team) could be improved. In addition, Geometric Pairing technology will be useful in making decisions for emerging architectures (i.e. Common Training Instrumentation Architecture). A variety of potential commercial applications of this technology exist. The high-fidelity geometric positioning technology may be used for commercial surveying operations. The same technology could be utilized by outdoor sportsman for hiking, boating, camping etc. Commercial systems produced from this technology could permit children to carry/wear position tracking systems in the form of jewelry, thereby reducing a wide variety of safety concerns. Additional commercial uses may be found for the entertainment industries, scientific measurements, and commercial shipping.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The cost of introducing notional indirect fire effects is eliminated. Indirect fire crews can test/train alongside their maneuver elements and their effectiveness evaluated based upon their effect during the event. This would reduce the need to train indirect fire crews separately, except for live fire, and provide commanders with greater knowledge in coordinating maneuver and supporting fire assets.

REFERENCES:
Joe R. Deres, Trivette, E.J.; Youmans, W. Cory; Technological Challenges for Geometric Pairing for the Dismounted Soldier

KEYWORDS: geometric pairing, ultra wide-band technologies, MILES, MAIS, testing, training, Future Combat Systems, dismounted troop, indirect fire weapons

A01-216 TITLE: Modeling and Simulation of Command, Control and Intelligence (C2I) Behaviors for the Objective Force

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM, ONE Semi-Automated Forces (OneSAF)

OBJECTIVE: To support assessment, training and mission rehearsal of the objective force develop realistic C2I surrogates that replicate command decision makers, are capable of learning and working under uncertainty.

DESCRIPTION: Future Combat System (FCS) and the objective force will increasingly rely on lower level decision making. Warfighters will be forced to make more complex and rapid decisions than ever before. To assess, train and conduct mission rehearsal will require believable adversary, and friendly forces C2I behavior modeling. Currently C2I is poorly modeled and requires man in the loop participation. This can be difficult to set up and limits the ability to assess, train and conduct mission rehearsals. To be truly effective these surrogates must be believable, unpredictable and adaptive to new situations. This should free simulations from lengthy setups, specialized locations and inadequate C2I representation. Surrogate development using process based artificial intelligence has inherent limitations caused by requirements for boundary definitions, are hard to maintain and require extensive knowledge engineering. Technologies that, offer much promise, and should be considered are: machine based learning and cognitive modeling as they offer the potential for low maintenance and relatively fast implementation without the overhead required by process based approaches.

PHASE I: Provide a functional analysis of the proposed system. Define, document and justify what the system is intended to do and how this will be achieved. The anticipated output should be a comprehensive systems description.

PHASE II: Build and demonstrate prototype C2I surrogates tool, Through the Joint Virtual Battlespace ATD, or with Future Combat System (FCS) concept systems experiments to be conducted at the Mounted maneuver battlelab.

PHASE III: These tools could provide the basis for effective operational decision aids, while providing realistic command and control operator surrogates for simulations. It is crucial to develop these technologies early in order to be able to make the objective force a reality. These technologies could form the basis of several commercial applications. Easily configured cognitive model based artificial intelligence would provide superior commercial website customer tracking systems and more believable interactive computer games. The technology could be applied to any complex domain such as air traffic control, space probes and autonomous robotics.

REFERENCES:
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2) Van Fossen, LTC Marion, "Future Combat Systems Brief to the AMSEC", PM-FCS, 6 November, 2000.
3) Brooks, Richard R., "Stigmergy - An intellegence metric for Emergent Distributed Behaviors", NIST/IEEE, Performance Metrics for Intelligent Systems Workshop Preliminary proceedings, 14 - 16 August 2000.
4) Friedlander, David, Phoha, Sasha, Ray, Asok, "Domain Independent measures of Intelligent Control", NIST/IEEE, Performance Metrics for Intelligent Systems Workshop Preliminary proceedings, 14 - 16 August 2000.

KEYWORDS: Command, Control, Intelligence, artificial intelligence, mission rehearsal, assessment and training

A01-217 TITLE: Advanced Materials for Enhancing High Voltage Power Converters

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this SIBR is to demonstrate a material/manufacturing process, which will provide a power converter that operates at a high continuous power range and provides a high peak and burst power for a heavy vehicle. This will require a power converter that demonstrates a power density of =/> 5.5kW/liter and capable of operating temperatures of >90 degrees C.

DESCRIPTION: The United States Army is investigating the use of hybrid electric propulsion systems in ground vehicles having gross vehicle weight ranging form 2.25 through 20 tons. Today's state-of-the-art technology for power converters provides the necessary capability for the lighter weight vehicles, but does not meet the requirements for the heavy (20 ton) technology demonstrators. Due to the horsepower needed to provide a heavy (20 ton) military vehicle the required/desired acceleration and sustained speeds require power converters with capabilities beyond the current state-of-the-art.

A hybrid electric propulsion system for a heavy military vehicle requires the ability to supply high peak power for vehicle acceleration. Storing energy in battery packs does this, which supplements the energy from a small conventional Internal Combustion Engine (ICE) & generator. A military combat vehicle needs to move quickly to and from covered positions. This burst power becomes a survivability factor by limiting the time the vehicle is exposed to direct observation by a threat.
Another characteristic of military vehicles, particularly a military combat vehicle, is the critical need to reduce the volume of any component "under armor". The existing technology used for high voltage power converters would require significant internal volume and a dedicated heat exchanger. High voltage power converters generate a significant amount of heat, which must be controlled. The state of the art in materials for these power converters cannot operate in high temperature environments.

The objective power converter must demonstrate the following. It must demonstrate a significant reduction in under armor volume (objective reduction of 50% in power converter volume). It also must demonstrate the ability to operate in high temperature environments (=/>90 degrees C). This will provide the operational characteristic required/desired in the heavy vehicles without the added requirement for a dedicated heat exchanger and its associated space claim.

PHASE I: Evaluate current commercially accepted materials and manufacturing methods and identify opportunities to extend their capabilities to meet or exceed the new objectives. Also evaluate opportunities presented by new materials and manufacturing methods to meet or exceed the new objectives.

PHASE II: Design, fabricate, test and report on high voltage power converters utilizing the new materials or manufacturing methods.

PHASE III: High voltage power converters have application to both military and commercial hybrid electric vehicles. The objective for this phase will be to design, fabricate, test and report on putting a high power converter in a existing heavy (20 ton) technology demonstrator. Also, it must show how this technology will improve performance to commercial hybrid vehicles.

REFERENCES:
NAC Hybrid web site - http://www.tacom.army.mil/tardec/nac/projects/hyb_veh.htm

KEYWORDS: high voltage power converters, hybrid electric, power converters, power converter materials, and power converter manufacturing.

A01-218 TITLE: Road and Terrain Characterization for Vehicle Dynamics and Mobility Analysis

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO, GROUND COMBAT AND SUPPORT SYSTEMS

OBJECTIVE: The objective of this research project to develop a method of characterizing terrain without assuming stationarity, Gaussinity or linearity. This project must find a model and derive a usable standard for the modeling and simulation community as well as the PMs and PEOs of vehicle systems.

DESCRIPTION: There needs to be a terrain model that reflects the true statistics of actual terrain. These statistics are not stationary, and are spatial in nature. This project will determine a statitical model for terrain that will characterize the ground, and feed into dynamics and fatigue models so that roughness of the terrain can be determined as a function of the dyanmics of the vehicle. A spatial terrain model should also be used to quickly produce detailed terrain for visualization and virtual war gaming.

PHASE I: Determine a list of approaches to deal with the nonstationary spatial terrain, and find the optimal method of characterizing the terrain. By optimal, the terrain must be accurately reproduced statitically, and with great speed so that modeling and simulation methods can be used. This method of characterizing terrain must be validated against actual terrain elevation data, and software must be written in MATLAB or C to visualize the terrain, and the characterizing functions.

PHASE II: A database of terrain models that characterize the statistics of different areas must be developed that is easily used with virual proving ground war simulations. The terrain models should be augmented with non-random objects such as tress, cliffs, rocks, and bushes. This augmentation must be done in a statistically reasonable way. Visualization demos and a war gaming scenero should be demonstrated and the terrain must be generated in real-time. The terrain data must enter in dynamics models to predict roughness to the vehicles, and forces that the vehicle sees. Vehicle roll-over should be predicted with higher accuracy. Vehicles will typically be robots with unusual dynamics. Thought must be given as to how the forces generated by the vehicle dynamics models will be entered into fatigue models.

PHASE III: The terrain and dynamics models must be integrated into fatigue models, and the models must be validated with actual test data on endurace of vehicle components. Theses models are of great commercial signifigance. Industry does not have a useful statistical model of roads and terrain, and has expressed intrest in learning about any models the Army might develop. These models could greatly improve dynamics and fatigue modeling, and reduce the cost of production and overdesign of all vehicle systems.

REFERNCES:
http://www.umtri.umich.edu/erd/roughness/

KEYWORDS: terrain, spatial statistics, dynamics, fatigue, modeling and simulation, RMSE, road roughness, nonstationary stochastic process.

A01-219 TITLE: Tribological Phenomena for Advanced Diesel Engines

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, FORCE PROJECTION

OBJECTIVE: Research, formulate, develop, and test/validate a tribological simulation capability for advanced diesel engines. Representative diesel engine tribological phenomena of interest include: ring pack optimization, engine wear prediction, oil film thickness and evaporation characteristics, blow-by and and sealing tradeoffs, friction quantification, three dimensional piston ring twist and wear, and lubrication properties appropriate for operation over wide ranges of temperature.

DESCRIPTION: The tribological research described within the Objective Section above is extremely relevant and important to future advanced diesel engines from within both the military and commercial sectors. The critical performance tradeoffs of diesel engine fuel economy, performance, life, durability, oil consumption, smoke, and other environmental considerations cannot be intelligently made without tremendous trial and error hardware prototype iterations, with huge expenditures of money and time necessary. The Army is particularly in need of the subject tribological simulation capability as it seeks innovative solutions to its future propulsion needs, including the Army's Future Combat Systems (FCS), over very short periods of time with minimum test and development cost. Increasing oil prices and more stringent environmental laws require an improved efficiency for future automotive engines, and the worldwide competition in the automotive market demands longer service intervals and engine life. These drivers further elevate the importance of the research of this topic area. Further, fuel economy improvement and enhanced power density are critical to both military and commercial applications. Unfortunately, a possible means of achieving these goals simultaneously involves increased engine speed and maximum cylinder pressure, and therefore the mechanical stress on the tribological system including the piston, piston rings, and cylinder liner is increased and the reliability decreases. The technical solution of these situations in advanced diesel engines absolutely requires greatly improved, fundamentally sound and sophisticated diesel engine tribological simulation capability.

PHASE I: Develop a preliminary version of an advanced diesel engine simulation approach which addresses factors such as: ring pack optimization in three dimensions, oil film thickness and evaporation characteristics, ring twist and blow-by, friction and wear quantification, and lubricant properties and characteristics over wide ranges of temperature. This simulation tool is to be capable of utilizing experimental diesel engine data to be collected during the engine hardware testing of Phase II, for the purpose of sophisticated tribological phenomena validation.

PHASE II: Design and develop an experimental advanced diesel engine test setup and test plan which will be used to validate the engine tribological simulation tool of Phase I. Use this experimental advanced diesel engine, instrumented with state-of-the-art sensors and controls, to validate and improve the simulation tool of Phase I. Establish Phase II outputs which will demonstrate the quantitative accuracy of the final tribological simulation tool and further describe projected sensitivity error bands when one attempts analytical tribological predictions of engine characteristics not in the immediate range of Phase II's experimental test plan. Phase II will utilize a synergistic and iterative methodology of anaysis/simulation and experimentation to produce an output product of greatest accuracy over a representative range of advanced diesel engines, with applicability to both military and commercial engines.

PHASE III: The output of Phase II wil be extensively used on current and future advanced diesel engines for both military and commercial engines. The outputs of Phase II will permit greatly decreased development costs to be achieved, in concert with significantly reduced development time, while allowing dramatic improvements to the engine's performance, fuel economy, and life.

OPERATION SUPPORT COST REDUCTION: The proposed research will have a huge effect on improved engine fuel economy, performance, wear characteristics, and development cost and time. The thrusts of the Army's Future Combat Systems (FCS) would be dramatically affected in a positive way by this research. Further, the opportunity for significant reduced lubricant consumption, as a result of this research, would permit great reductions in the logistical tail of the Army's future vehicles.

REFERENCES:

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2) D. Taraza, N. Henein, W. Bryzik, "Experimental Determination of the Instantaneous Frictional Torque in Multicylinder Engines", SAE Paper No. 962006, 1996.

3) D. Taraza, N. Henein, and W. Bryzik, "Frictional Losses in Multi-Cylinder Diesel Engines", SAE Paper No. 2000-01-0921 (2000).

4) R. Stanley, D. Taraza, N. Henein and W. Bryzik, "A Simplified Model of the Piston Ring Assembly", SAE Paper No. 1999-01-0974 (1999).

5) N. Henein, M. Z. Ma, S. Huang, W. Bryzik and J. Glide Well, "In-Situ Wear Measuring Technique in Engine Cylinders," Society of Tribology and Lubrication Engineers, Tribology Transactions, Vol. 41, No. 4, pp. 579-585, 1998.

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KEYWORDS: Tribology, piston rings, friction, wear, lubricant, advanced diesel engines, oil film thickness.

A01-220 TITLE: New Electrode Materials for Batteries and Fuel Cells

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM:

OBJECTIVE: Seeks the development of new electrode materials for application in fuel cells.

DESCRIPTION: New electrode materials are needed for polymer electrolyte membrane fuel cell applications which are lightweight, stable for long periods, easy to fabricate, and inexpensive. These materials should also have good electrical properties, and be resistant to chemical attack under harsh operating conditions. These materials could serve as electrode materials, current collectors, electrocatalysts, or all of the above. Applications include polymer electrolyte membrane (PEM) fuel cells for mobile (i.e. genset) or vehicle based power generation. Most of the current materials employed typically have drawbacks such as excess weight (e.g.- porous metals), limited lifetimes, or poor electrical performance (e.g.- glassy carbon materials). This solicitation seeks the development of materials that significantly advance the current state of electrode technology. These advances may include, but are not limited to CO tolerant electrodes, electrodes with improved heat transfer characteristics, electrode or support materials with improved lifetimes and electrical performance, materials with large improvements in weight or structural integrity, or unique integration of the electrolyte/electrode systems. Candidate materials may include graphitic carbon materials, conductive polymers, or composite inorganic-polymer systems. The proposed research should address both the technical and the economic viability of the new systems, and clearly outline the experimental and computational analyses to be performed.

PHASE I: Identify electrode chemistries, target applications, and potential performance improvements. Perform initial performance evaluation of promising chemistries. A detailed plan for the continuation of experimental and computational analyses to be performed in Phase II must be in place.

PHASE II: Develop and test electrode material to demonstrate performance, weight, manufacturability or affordability improvements over existing materials. Incorporate the new electrode into a prototype unit (i.e. battery or fuel cell) and demonstrate its applicability to commercial and military systems. Evaluation of the prototype should include a demonstration of performance improvements in the areas durability, power density, and/or cost effectiveness.

PHASE III: Potential commercial applications for PEM fuel cells include drive and auxiliary power for vehicles, and stationary and personal power generation. The military has similar electric power demands in all of these areas. Additionally, a variety of battery chemistries both in military and commercial service could benefit from improved performance.

REFERENCES:
1) Hirschenhofer, J., D. Stauffer, R. Engleman, and M. Klett. 1998. Fuel Cell Handbook Fourth Edition, U.S. Department of Energy - FETL, Morgantown, WV.
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KEYWORDS: electrode, PEM, fuel cell

A01-221 TITLE: Inovative Energy Storage for Hybrid Electric Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM M113

OBJECTIVE: The objective is the identification of materials and technology which will be able to store and deliver large amounts of energy over a short time duration across a wide temperature range. The device should not need external heating and/or cooling and be capable of operating from -25 F to 150 F, a target power density [W/kg] of greater then 300 W/kg and a cycle life of greater then 1000 cycles at 75% depth of discharge.

DESCRIPTION: This capability is needed as hybrid electric vehicles continue to improve. A characteristic of a military vehicle, particularly a military combat vehicle is the critical need to reduce the volume of any component "under armor". The existing energy storage devices require significant volume and in some cases a dedicated heating and cooling system. The objective energy storage devices must demonstrate significant reductions in under armor volume and operate over a wide temperature range. This technology would have a large dual-use application as more and more of the automotive industry is developing hybrid electric cars and trucks.

PHASE I: Evaluate current commercially accepted materials and technologies and identify opportunities to extend their capabilities to meet or exceed the new objectives. Also evaluate opportunities presented by new materials and manufacturing methods to meet or exceed the new objectives.

PHASE II: Design, fabricate, test and report on energy storage devices utilizing the new materials or manufacturing methods.

PHASE III: Storage devices have application to both military and commercial hybrid electric vehicles. For phase III the following needs to occur. Update design after the Phase II testing and deliver an energy storage device that can be integrated onto a hybrid testbed either commercial or military.

REFERENCES:
1) SAE Technical Paper 981905 - Performance, Management and Testing Requirements for Hybrid Electric Vehicle Batteries.
2) SAE Technical Paper 2000-01-1604 - Advanced Automotive Technologies Energy Storage R&D Programs at the U.S. Department of Energy - Recent Achievements and Current Status.
3) NAC Hybrid web site - http://www.tacom.army.mil/tardec/nac/projects/hyb_veh.htm

KEYWORDS: energy storage, hybrid electric, power storage, and battery.

A01-222 TITLE: Simulator Monitor and Control (SMAC) System

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM:

OBJECTIVE: Design and build a simulator monitor and control (SMAC) system workstation that would give Simulation Centers a means to safely and effectively run laboratory-based simulations in a cost-effective fashion.

DESCRIPTION: Vehicle simulators are being more of a common place in Automotive and Defense Research and Technical Centers. Most Centers regularly utilize driving, combat, and/or immersive environment simulators as a means to speed up the vehicle development process and to quickly prove out component and operational schemes. However, many of these simulators still require experts to configure, operate, and to interpret data resultant from experiments carried out on them. As such, the need

to produce user-friendly operator and control workstations, yet remain flexible to changing requirements in the complex vehicle development process is clearly evident both at Army sites and private industry. The resultant product is marketable as several major simulation laboratories are in development now. The SMAC would provide a convenient workstation with features and capabilities to:

- develop and edit the virtual environment which specifies the particular simulation to be run.
- control the real-time execution of the simulation.
- monitor measure, collect, and analyze real-time simulation performance data.
- convey to the customer a capability to get rapid results and to interact with the simulation.

PHASE I: Develop an overall concept design that includes specifications for a simulator operator station. Demonstrate concepts resulting in a simulation laboratory environment.

PHASE II: Conduct full development and delivery of a SMAC system and integrate into motion-based simulation facilities. Set appropriate tuning parameters for optimal simulation facility and conduct demonstrations.

PHASE III: The SMAC would have broad applications with 1st and 2nd tier suppliers in the automotive industry who conduct driving and ride comfort simulations for vehicle design. The aircraft industry also employs similar Simulation Centers. The SMAC would be the means to user-friendly operation of such facilities.

REFERENCES:

1) Watson, G., Papelis, Y., Multi-media Interactive Data Verification and Reduction Tool for use in Driving Simulator Research, Image 2000 Conference.

2) National Advanced Driving Simulator Development Specification, 1997.

KEYWORDS: simulator, real-time, virtual environment, tuning.

A01-223 TITLE: Mine Blast Resistant Track

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: To establish a set of minimum requirements that a track system and vehicle underbody must be capable of withstanding to be considered mine resistant. Identify a potential solution to meet these requirements and evaluate it through testing at Aberdeen Proving Ground (APG).

DESCRIPTION: Every track system used by the military and nonmilitary must provide a level of protection to the roads that they are operated on. Materials that the Government develops to increase or prolong this level of protection could also be used by the commercial industries to improve their levels of protection as well. Advances in lighter/stronger track materials and designs could be implemented by the commercial industries to increase the capacities, and performance of their vehicles. The proliferation and use of mines throughout the world and the need to clear them after hostilities cease has increased the exposure of commercial vehicles to mine hazards. This technology would also have applications in force protection, security vehicles, police bomb squads and SWAT teams, crowd control vehicles and a host of other commercial applications. Material development under this program would also have use in commercial aircraft cargo containers to ensure that in the event of an explostion, it will be contained within the container allowing the aircraft to safely land.

PHASE I: Develop a feasiblity concept design.

PHASE II: Demonstrate a prototype capable of scaling up to the military application. The design should allow for flexiblity to dual use applications.

PHASE III: Production of mulitple modules for live testing including one private sector application, such as a police bomb squad vehicle, or a commercial aircraft baggage container.

OPERATING AND SUPPORT COST REDUCTION: Increased mine blast resistance in track laying vehicles will prolong the life of the track after contact with a mine, and could potentially save the lives of the vehicles crew by allowing the vehicle to stay mobile and continue toward its objective or retire from combat safely. A mine blast resistant track may offer other unknown benefits at this time such as increased durability.

REFERENCES:
1) Band Track Test, ATC Mine Blast Resistance Testing (To request a copy of this test contact Jason Alef (810) 574-6376, alefj@tacom.army.mil
2) Ballistic test at ATC on the ADI T154 (To request a copy of this test contact person above).

KEYWORDS: Track, Combat Vehicles, Mine Resistance, Mine Blast, Mine Blast Protection, Survivability

A01-224 TITLE: Potable Water Generation

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Petroleum and Water Systems

OBJECTIVE: The objective of this project is to develop a scalable energy-efficient technology to generate potable water from non-traditional sources. This technology must be adaptable to compact, rugged, mobile, water generation systems to support soldiers deployed in field environments.

DESCRIPTION: Water purification technology has undergone significant advances in the past few decades, however, water sustainment on the battlefield still follows the age old practice of locating a water source, treating the water to make it potable, and then transporting the water in bulky containers to the soldiers. For the current forces over half of the sustainment requirement is the distribution of bulk liquids. As the Army evolves into a lighter and more deployable force focused on the concept of force projection water distribution becomes an even larger concern for military logistics. In fact, current projections indicate that water will become the single largest logistics requirement for the Army. The ability to generate water at the point of use would reduce or even eliminate the transportation requirement and have a cascading effect on reducing the overall logistics requirement of the force.

The goal is to develop a system that has the capability to generate water on demand when no traditional source (i.e. river, lake, or ocean) is available. One source for the system would be atmospheric humidity, however, original concepts using other non-traditional sources available in all environments will be considered. The Army is not interested in simple refrigeration systems but rather novel technologies that reduce the energy requirements, size, and weight of the system. Possible approaches include water generation by means of tailoring and being able to tune surface characteristics (hydrophilicity/hydrophobicity, charge) of high surface area materials that are constructed with optimized structures (lengths, diameters, angles, porosity, surface chemistry) to promote water condensation. The technology should be scalable for applications ranging from collecting moisture from a soldier's breath to bulk generation systems collecting moisture from the atmosphere. The device must be able to generate potable water in sufficient quantities in all environments, including nuclear, chemical and biologically contaminated areas. The water generation units should be scalable to any size, sustainable, and generate enough water to be of use to the DoD in a timely fashion. As a baseline the system should have a production rate at least equal to the current military systems, for traditional sources, of the same size, weight, and power consumption.

PHASE I: Develop conceptual designs, asses designs, and perform analysis to predict system behavior and efficiencies. Demonstrate concept feasibility for the generation of drinking water in a laboratory environment.

PHASE II: Select application/design for prototype development. Conduct sub-component design, fabrication, and testing for critical components and subassemblies. This phase would include the integration, assembly, and performance testing of a prototype water generation device. Testing should be robust enough in this phase to assess performance, capability, durability, and capacity of water generation devices.

PHASE III: These devices would have a broad range of military and civilian applications where traditional water sources are scarce. The systems could sustain or augment the water resources of small units, travelers, remote facilities, and even small settlements in arid environments.

REFERENCES:
1) Bagwell T.H., Shalewitz B., and Coleman A., "The Army water supply program: An overview," Desalination, v99, p409-421, 1994
2) Directorate of Combat Developments for Quartermaster (DCDQM), www.cascom.lee.army.mil/quartermaster
3) FM 10-52, Water Supply In Theaters of Operation, 1990 (see DCDQM website)
4) FM 10-52-1 Water Supply Point Equipment and Operations, 1991 (see DCDQM website)
5) U.S. Army Functional Concept For Potable Water Support (see DCDQM website)
6) Potable Water Planning Guide, 1999 (see DCDQM website)

7) U.S. Army Center For Health Promotion and Preventative Medicine (CHPPM), http://chppm-www.apgea.army.mil
8) TB Med 577, Sanitary Control and Surveillance of Field Water Supplies (see CHPPM website)
9) TRADOC Pam 525-66, Future Operational Capability, 1997, 1999, FOC QM97-003, QM99-003, (www.tradoc.army.mil)
10) Army Science Board Summer Study 2000 (www.sarda.army.mil)

KEYWORDS: Potable Water

A01-225 TITLE: Optically Clear Low Damage Threshold Materials

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop an optically clear, very low damage threshold material, that provides ocular protection against visible pulsed lasers. (The goal of this work is to obtain a needed level of eye protection from lasers in the near term, while research continues to develop nonlinearly transmitting devices which have greater dynamic range and full recovery).

DESCRIPTION: Laser protection is a requirement on all combat vehicle optical & electro-optical systems. For this effort, we request a sacrificial material that has a fairly high transmission under normal scene illumination, but damages or undergoes a permanent phase change when exposed to intense laser radiation and attenuates almost all of the incident laser light. When exposed to a 5-10 nanosecond Full Width, Half Maximum (FWHM),
Q-switched laser pulse, this sacrificial material must damage in less than a nanosecond and attenuate the laser light enough to prevent eye damage. It must have a broadband response that covers the entire visible spectrum. In addition, the material shall have a linear, luminance transmittance of 70% or greater and it's performance shall not be degraded when exposed to solar radiation.

PHASE I: Investigate sacrificial materials and develop methods to fabricate a protective device. Deliver one sample to the government for laser testing.

PHASE II: Refine and improve materials investigated under Phase I to lower the initiation threshold while increasing the luminous transmittance of the material. Deliver improved sample to the government for laser testing.

PHASE III: The material developed under this effort would have numerous applications such as safety equipment, space-based protection, and optical data storage.

REFERENCES:
ANSI Z136.1, Safe Use of Lasers, 1993.

KEYWORDS: Laser Protection, Sacrificial Material, Optical, Damage Threshold

A01-226 TITLE: Micromachine Robot for Automotive Diagnotstics, Visualization & Sensing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO, GROUND COMBAT AND SUPPORT SYSTEMS

OBJECTIVE: To provide a set of tools for logistics and maintanence personnel to improve the diagnostics process of vehicle systems. This tool will be unique in its use of micromachines for smart sensing and diagnostics of vehicles.

DESCRIPTION: Great advances in sensors and micromachine technology and nanotechnology, used in Micro Electro-Mechanical System(MEMS), allows for new sensors and machines to aid in vehicle diagnostics and prognostics. The micromachine must interface using sensors with vehicles in the field to diagnose problems with the vehicle and perform prognostics. This new information provided to the vehicle and maintenance staff should be integrated onto the vehicles data bus, and should interface with the computer control systems and other vehicle intelligence systems.

PHASE I: To determine the possible methods to diagnose vehicles in the field (without pulling the vehicles into a shop area) using micromachines, and access the value and feasiblity of those methods. Prognostics is of equal importance. As an example, the high pressure hydraulic systems on trucks can be easily destroyed once contaminated with something as small as a few grains

of sand. Intelligence sensors may detect and prevent failure by finding the contamination before seals are broken or pressure is lost. Research current micro machines and determine which ones will be useful in this application. Use a micro machine to demonstrate how some aspect of the vehicles systems can be diagnosed and used as a tool for Logistic Area Representatives (LARs).

PHASE II: Implement the diagnostics and prognostics micromachines, senors and nanotechnologies on a vehicle system and demonstrate its usefulness to logistics and maintenance personnel (LARs). Create the user interfaces and data acquisition systems to improve the useability of the tool. Demonstrate the cost effectiveness of the tool, and its performance at diagnosing problems. Make sure that the new tools are integrated into the maintanance processes of the vehicle.

PHASE III: A useful LARs tool would be directly applicable to the commercial automotive industry. There is a need for adaptable micromachine diagnostics tools that can improve the diagnostics capabilities of current systems analysis tools with unique sensors and machines. Improved diagnostics can greatly reduce the maintenance costs of vehicles.

REFERENCES:
1) National Nanotechnology Initiative http://www.nano.gov/
2) The Commercialization of Microsystems 2000 http://asm.unm.edu/mot/coms/AbstractsSpeakers.htm

KEYWORDS: micromachines, diagnostics, automotive test, prognostics

A01-227 TITLE: <u>Exhaust Impingement Effects Predictive Capability for Future Combat Systems (FCS) and the 21st Century Truck</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM CRUSADER

OBJECTIVE: To research, design, prototype and demonstrate an innovative predictive tool of the effects of exhaust impingement for Future Combat System(FCS) and 21st Century Truck.

DESCRIPTION: In the design of commercial and military vehicles, the engine exhaust must be carefully considered. From a military standpoint, survivability requires the total thermal management of a system with particular emphasis on the exhaust. Target and ground impingement of exhaust gases are an important piece of the overall thermal signature management puzzle. In order for the Future Combat System to be lighter, its survivability is going to rely more on not being seen in the first place. This type of enhanced predictive capability would reduce the risk of design engineers being able accomplish their survivability goal during the fast track acquisition cycle currently in place. In addition, tactical vehicles are more vulnerable to detection as infrared sensors become cheaper and more prolific in the battlefield.

Safety is both a military and commercial concern. For safety purposes, both the ducting and exhaust gases on vehicles must be managed in such a manner as to prevent over heating of target areas of the vehicle or personnel.

A new methodology is needed to interface between the thermal predictive tools of targets and backgrounds and the synthetic natural environments (SNEs) under development by DoD. The interplay between the two has always been a challenge, but the need for this capability is ever increasing as the acquisition process becomes streamlined. Currently, temperature predictive tools such as MuSES, PRISM, GTSIG, IRMA (IR predictive component) are utilized by SNE rendering packages such as Paint-the-Night, CREATION, GTSIMS, and IRMA (rendering component). What is missing is a robust exhaust impingement tool based more on first principles that will allow the designer to optimize the exhaust system. Computation Fluid Flow links, links to the SNE renderer, and special material properties must all be taken into consideration.

PHASE I: The contractor shall design and develop a methodology to predict exhaust impingement onto targets (self-impingement) and onto backgrounds (ground, tree-lines, shrubs, grasses etc). This shall include the self-impingement effects on advanced materials.

PHASE II: The contractor shall extend the methodology from Phase I into a prototype full capability tool utilizing the Multi-Service Electro-optical Signature Code (MuSES) and one of the above mentioned SNEs.

PHASE III: Radtherm (a derivative of MuSES) is an established tool in the commercial market and this capability, if demonstrated using MuSES, could be an add-on feature to Radtherm for the automotive market. The application would be safety as well as total thermal management (as outlined in the Cooperative Research Agreements currently active between the Ford Motor Company and TARDEC)

REFERENCES:
References are contained in TRADOC FOC's: TR 97-057 and TR97-043 to 045; and Battlelab FOC's: AR97-203; IN97-100, 160, 210, 220, & 240; MMB97-008, 009, MMB 97-018, MMB 97-020;FA97-003; DSA97-004;EN 97-003; EN 97-030, EN97-103; and MSB97-008. PITAC - Report to the President Information Technology: Transforming our Society, Chapter 1.7 Transforming How We Design and Build Things "High-end computing technologies are needed for concept design, simulation, analysis with interactive control and computation steering, the mining of archived data, and the rendering of data for display and analysis." K. Johnson et al, "MuSES: A New Heat and Signature Management Design Tool for Virtual Prototyping,: Ninth Annual Ground Target Modeling & Validation Conference, Houghton, MI USA, Aug 1998; A. Curran, S. Dudley, "Automated Radiation Modeling for Vehicle Thermal Management," 1995 SAE International Congress and Exposition, Exhaust Systems &shielding SEssion, Paper Number 950615, Detroint MI USA, Mar 1995.

KEYWORDS: Modeling and Simulation, Signature Management, Thermal Management, Exhaust, Hybrid-electric, HEV, Ground Vehicles, 21st Century Truck, synthetic natural environment, SNE.

A01-228 TITLE: Inducing Retained Compressive Stresses for the Design of Lightweight Tough Composite Material Structures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM. Bradley Fighting Vehicle

OBJECTIVE: Develop a design methodology for designing discontinuous fiber reinforced metal matrix composite (such as silicon carbide reinforced aluminum metal matrix composites) for Army applications. Select a Metal Matrix Composite (MMC) manufacturing process based on low cost and capability for near-net-shape fabrication of complex components with minimal machining and joining requirements (such as squeeze casting). Improve the toughness of MMC by introducing the retained compressive stresses in the MMC via the use of shape memory alloys [1]. The newly developed composite with SMA should have 75-80 percent of the toughness of steel as measured by fracture toughness (KIC) [Reference 2] and Charpy impact toughness [Reference 3], and should have a density 20-25 percent lighter than steel.

DESCRIPTION: The proposed weight goals for the U. S. Army's future combat system (FCS) land vehicles emphasizes the development of new design methodologies and manufacturing processes. The projected technologies include use of smart materials and validated manufacturing processes for improved performance and weight reduction. The characteristics of discontinuous fibers (for example whiskers and particulates) allow the use of reinforcement to improve properties in MMC [4]. The properties improved through reinforcing metals with whiskers and particulates are insufficient for the Army needs to meet the toughness goals at cold and elevated temperatures.

Aluminum alloys have recently been processed with retained compressive stresses via shape memory alloys (SMA) and has shown substantial increase in tensile properties, fatigue resistance (crack growth retardation) at high temperatures and also increase in resistance to fracture [Reference 1]. The use of shape memory alloys to aluminum showed unique properties such as self-strengthening by the compressive stresses in aluminum matrix due to the shape memory shrinkage of the embedded smart material.

Relationships for estimating the composite properties based on the properties and concentration of the constituents and from the internal microstructure has emerged as an essential component of the design technology of composite materials [5]. Such analytical solutions should be available for fracture and impact toughness of discontinuously reinforced fiber reinforced MMC.

PHASE I: Identify the most promising reinforcement (such as silicon carbide particulate, whiskers etc) and matrix (such as aluminum) for composite processing. Introduce the shape memory alloy (SMA) into the composites to induce retained compressive stresses. Determine the correct proportions of the reinforcement and SMA to produce a dense composite with good interfacial properties and retained compressive stresses. Process the composite using a low cost manufacturing process. Develop a screening methodology for a quick evaluation of the composite through tests for fracture toughness (KIC), impact toughness, tensile and wear properties at room temperature (75 F), -65 F, and +300 F temperatures. Demonstrate the feasibility to produce a fully dense silicon carbide composite having fracture toughness and impact toughness of 75-80 percent of the that of steel. The density should be 20-25 percent lighter than steel. Down select an Army MMC part such as track shoe of a combat vehicle for evaluation in Phase II.

PHASE II: Conduct a detailed evaluation of the MMC for the desired density, and toughness goals. Evaluate by experiments and analysis, tensile properties, fracture toughness (KIC), impact toughness, and wear properties of the composite at room temperature (75 F), - 65 F, +300 F and compare it with that of hardened steel. Use analytical models for estimating the elastic

constants. Design, process, fabricate and test an Army application such as track shoes of the existing typical combat vehicles selected in Phase I. Develop FEM models of the selected part and perform stress analysis using the loads that occur in the tracks of Army vehicles. Verify the analytical results by laboratory tests on the structural component under loads applied in the analysis.Scale-up design, testing, analysis and processing to produce successfully track shoes for the Army tracked combat vehicles.

PHASE III: Discontinuous fiber reinforced metal matrix composite technology if demonstrated for track shoe applications,will be a useful techology for many other automotive and engine applications.The automotive industry may be interested to use this MMC for engine and advanced propulsion systems. For example, piston rings, flanges, turbo pump housings, thrust chamber jackets, impellers, brakes shoes, and other applications.

If this technology is demonstrated to be successful, the Bradley Fighting Vehicles program may be interested to field test the MMC track shoes on Bradley Fighting Vehicle track through a non-SBIR program such as the one presently underway at TARDEC.

REFERENCES:
1) Yasubumi Furuya, "Design and Material Evaluation of Shape Memory Composites," J. Intelligent Material Systems and Structures, 7, May 1996, 321-330.
2) ASTM E 399-90, Standard Test Method for Plane-Strain Fracture Toughness of Metallic Materials, ASTM Annual Book of ASTM Standards, Volume 3.01, 1997, 408-438.
3) ASTM E 23-96, Standard Test Method for Notched Bar Testing of Metallic Materials, ASTM Annual Book of ASTM Standards, Volume 3.01, 1997, 137-156.
4) Raju, B., D. Liu and T. Richman, "Energy Absorbing Capability of SiCp /SiCw /Al Composites," Proceedings of the American Society for Composites, 15th Technical Conference, College Station, TX, September 2000, 923-934.
5) Eduljee R. F. and R.L. McCullough, "Elastic Properties of Composites; Continuos Fiber, Particulate, and Discontinuous Fiber,' CCM Report 93-07, University of Delaware Center for Composite Materials, February, 1993.

KEYWORDS: Metal Matrix Composites(MMC), Shape Memory Alloys (SMA), Track Shoes, Silicon Carbide Discontinuos Reinforecement, Cast Aluminum

A01-229 TITLE: Lightweight Metal Structures for Future Fuel-Efficient Army Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM IMPACT, National Automotive Center, TARDEC

OBJECTIVE: Develop a methodology to design components made of new and emerging engineered materials to enhance the performance and reduce weight of both military and commercial ground vehicles. The methodologies to be developed should lead to significant improvements in the removal of vehicle mass (40 to 50 % weight reduction), and good vibration characteristics. This methodology should also provide better impact and crash energy management. The efforts of this program should result in fuel-efficient and high performance Army and commercial ground vehicles.

DESCRIPTION: The U.S. Army Tank-automotive & Armaments command (TACOM) is developing high performance combat vehicles and fuel-efficient, lightweight tactical vehicles. Two major Army programs are Future Combat Systems and 21st Century Truck program. These Army ground vehicles are required to have high performance with respect to high velocity impact, and lighter so that they are more mobile and deployable. The commercial trucks should have high crash energy energy management besides being fuel-efficient.

Engineered materials falls into 2 categories: (1) Sandwich structures with light weight metal foams, or metal matrix composite armor as core materials; (2) Geometrically engineered materials such as LBM and MicroPerf. Metallic foams are a new class of materials with low densities, which could be made for example from aluminum, which can be used in automotive body structures [Reference 1]. The metal foams provide good mechanical damping, vibration control, acoustic noise absorption, impact energy and thermal management. The metal matrix composite armor is an emerging new material technology for lightweight armor, as an alternative to conventional armor materials for military ground vehicles. For example functionally graded materials offer exciting possibilities for armor, armaments and vehicle structures [2]. The geometrically engineered materials such as Lattice

Block Material (LMB) and MicroPerf are emerging for very light weight applications involved in high impact and crash energy management systems [3 & 4]. Maturing these emerging engineered materials technologies for Army applications can be accomplished only through an R & D effort on design optimization, analysis, testing and manufacturing aspects of these new emerging technologies.

PHASE I: Demonstrate the design and manufacturing methodology for making simple Army and commercial ground vehicle components from the engineered materials referred above. Demonstrate the weight reduction of 40 to 50 percent compared to the existing metal structures. Identify at least one Army ground vehicle components and one commercial truck component for detailed R & D effort in Phase II.

PHASE II: Develop optimized structures design for the Army ground vehicle and commercial truck components selected in Phase I. Use finite element analysis such as homogenization method in conjunction with topology optimization methods to reduce the structural weight and improve vibration characteristics and impact resistance [5 –7]. For military ground vehicles, high velocity impact (Ballistic) should be the primary consideration. For commercial trucks, vibration and crash energy management should be the primary considerations. Demonstrate the optimized design on components for Army Ground vehicles and commercial truck platforms through structural tests.

PHASE III: A successful lightweight engineered material technology will find applications both in the Army combat and tactical vehicles and also commercial trucks to reduce weight and improve the performance. Dual use application would increase the opportunity for affordable implementation of this technology enabling the Army to meet the goals for future fuel-efficient and high performance ground vehicles.

REFRENCES:
1) Michel F. Ashby et al, Metal Foams – A design Guide, Butterworth/Heinemann, 2000.
2) Cherradi, N., A. Kawaski and M. Gaski, "Worldwide trends in functionally gradient materials (FGM) research and development," Composite Engineering 4 (1994) 883-894.
3) ___________ "Development of Lattice Block Materials as an Ultra-Light Steel Fabrication Technology Techniques," Navy SBIR Phase II Report No. 3, JAMCORP, MA 2000
4) __________ "Demonstration of the manufacturing of Lattice Block Materials as a solid Freeform Fabrication Technique," Air Force Final Reports, Nos. 1, 2 and 3, AF98-98227, JAMCORP, MA 1998.
5) Ma, Z. D., N. Kikuchi and H. C. Cheng, "Topological Design for Vibrating Structures," Comp. Method. Appl. Mech. Eng., 121 (1955), 259-280.
6) Hassani, B., and Hinton, E., Homogenization and Structural Topological Optimization, Springer Verlag, 1999.
7) Kukichi, N., K. Suzuki and J. Fukushima, "Layout Optimization using the homogenization method: generalized layout design of three-dimensional shells for car bodies," Optimization of Large Structural Systems, NATO-ASI Series, Vol. 3 Berchtesgaden, 1991 110-126.

KEY WORDS: Engineered Materials and Structures, Metal Matrix Composite Armor, Functionally Graded Materials (FGM), Lattice Block Materials (LBM), MicroPerf.

A01-230 TITLE: Variable Suspension System

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: To reduce the time it takes to change out track on a vehicle and provide a safer operating environment for the maintenance worker and soldier.

DESCRIPTION: Current track systems require a large effort to change individual track shoes or the whole track. With the development of a suspension system that allows maintenance personnel control over individual road wheels, drive sprockets and idlers the vehicle track would be adjusted remotely; this idea would enable maintenance personnel to pivot individual roadwheel stations, the drive sprocket or idler to ease installation of the track onto the vehicle. More so, the sprocket, idler and roadwheels could be preset at a "ground" level which, when maintenance personnel hits a button a program would reset the idler, sprocket or roadwheel(s) to their normal positions. This would enable a two, to three-person job, to be accomplished with only one or two people in a fraction of the time. This would also allow for the maintenance worker to avoid the risks associated with elevating a heavy vehicle off the ground to change the track.

PHASE I: Design a variable suspension system to ease in track maintenance for medium weight (up to 30 tons) track laying vehicles.

PHASE II: Develop and fabricate a prototype system for the Government; and fabricate a second prototype for demonstration of the variable suspension system, at the Government's expense. Exisiting vehicle track, roadwheels, drive sprocket and idler will be used.

PHASE III: Deliver of four units to the Government for durability and performance testing. Variable suspension systems are equally applicable to both military and commercial track laying vehicles. Current commercial grade construction and agricultural vehicles have transistioned to using a track for mobility. All current tracks will wear out over time and it then becomes necessary to change them. The current methods for changing the track are crude at best, often lifting the vehicle to remove the track and reinstall it. This creates several potentially disasterous circumstances for the installers. The variable suspension system will reduce the need to elevate the vehicle increasing operator safety as well as lower the amount of vehicle down time.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Reduction of the number of maintenance and personnel hours necessary to change vehicle track will allow the maintenance personnel to perform other functions on or about the vehicle, thus maximizing their time for other applications. The variable suspension system will also eliminate the need to elevate the vehicle which reduces the users risk around the vehicle when changing the track. The variable suspension system will also eliminate the need for other expensive and often unavailable equipment in the combat environment to install the track. The system will also reduce the amount of time necessary to install the track if the vehicle crew is in a hostile situation away from a maintenance facility or maintenance personnel.

REFERENCES:
TECOM Project No. 1-VC-010-113-127 Summary Test Report for the Technical Feasiblity of the Experimental Band Track for the M113 Armored Personnel Carriers Initial Reconditioning Test; This report showcases some of the installation of the band track and the difficulties presented therein.

KEYWORDS: Combat Vehicle Suspensions, Variable Suspensions, Optimization of Suspension System

A01-231 TITLE: High-Speed Data Communications (Integrated Solutions)

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM:

OBJECTIVE: The objective of this program is to continue development of a High-Speed communications technology, which complies with current Mil-Std requirements, add the ability to transmit critical data with voice and video, supports multiple protocols and to demonstrate via a Brass Board on vehicle.

DESCRIPTION: Current Mil-Std 1553 networks operate at 1 Mbps. Although the standard is in current use, the data speeds have limited it to mission critical systems use exclusively. Upgrades require the same robustness and determinism as Mil-Std 1553 while achieving substantially higher data rates (100Mbps to 300Mbps). In addition to increasing data rates, other important factors are maintaining current cable plants and their couplers, supporting existing protocols to reduce software impacts and incorporating digital voice and video on the same networks thus reducing costs, footprint, power and noise of analog voice and video. The solution is provided at the lowest level of data communication, the physical layer. This is the layer that talks to the wire or cable. The proposed solution uses noise suppression to increase the Signal to Noise Ratio 8dB. This increase allows for the higher data rates, longer transmission ranges, lower power and allows for an unbreakable security scheme which subtantially reduces encryption and decryption overhead as with current security schemes.

Phase I: The core technology has been developed and demonstrated in the R&D lab. The state of development demonstrates 100+ Megabits per Second raw data transfer rates over a Mil-Std1553 drop bus, passive coupled network with a Bit Error Rate of 10-10. Phase I will provide a study on current and proposed network structures and architectures used in both commercial and defense applications and determine which signaling techniques and protocols would best support current applications with minimal impact while increasing performance. The intent is to incorporate a protocol mapping Digital Signal Processed interface that would support current Mil-Std protocols and COTS protocols while maintaining mission critical Time Division Multiplexed TDM deterministic data deliver supporting Voice Video and Data multimedia services. This architecture allows for a distributed switch fabric that dynamically supports all predetermined protocols. Technical risk thus far has been low by virtue of a 94% digital design and use of an FPGA development platform or logic programmable integrated circuit. The 100 Mbps speeds are supported by the devices allowing for low cost debugging and Engineering Change without the need for expensive silicon foundries. The current Tensilica System on Chip (SoC) provides the DSP engine required for dynamic protocol mapping while supporting data path control. Technical risks are associated with EMI/EMC testing while using FPGA development platforms. Testable units will require a code migration to a programmable Application Specific Integrated Circuit (ASIC) in order to test for

Mil-Std461 compliance. All other interoperability testing and application level functional testing can be accurately simulated with Engineering Design Tools (EDA). low cost demonstration and weigh the added value of an implementation. A system level design will result from the Phase I effort including the requirements needed to create a brass board on vehicle demonstration. Phase I would provide the guidelines for a truly open architect.

Phase II: Incorporates the findings from Phase I into a fully functional Brass Board which demonstrates the flexibility of a distributed switch fabric supporting protocols required by study Phase I. The distributed switch services will allow for multi-protocol operation over the network and provide the same deterministic mechanism as with Mil-Std1553 Manchester coding on all protocols i.e. (Mil-Std 1553, FC, Ethernet/IP, Fire Wire, etc..) while supporting Voice and Video multimedia services. The R&D Brass Board is suitable for initial demonstration on vehicle using current cable plants to demonstrate interoperability with current bus networks while delivering 100Mbps mission critical data, voice and video simultaneously. Current COTS solutions use Point-to-Point architectures as with Ethernet, which require a central switch. Because each node must pass data through this star topology network and data is in packets that can be different in size, the data cannot be delivered in a guaranteed time frame. There are no known solutions that can allow high data transfer rates in a guaranteed time frame and operate over a shared bus topology with the support of multi-protocol.

PHASE III: The military applications include high-speed networks, MIL-STD 1553 data buses with substantially higher data rates, incorporating digital voice and video on the sames networks, and reduced encryption and decryption effort.

Phase III commercial applications include: faster secure Police data transfer, high-speed communications technology, incorpoating digital voice and video on the same networks.

REFERENCES:

The web site www.mobildynamic.com has much information on this subject. The information can be found at various places on the site but especially under the "Press" section.

KEYWORDS: High-speed data transfer, wireless secure voice and data communication, Mil-Std 1553, and open ended architecture.

A01-232 TITLE: <u>Simplified Radar Configuration Evaluation Tool</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Battlespace

ACQUISITION PROGRAM: PM Future Scout and Cavalry System(FSCS)

OBJECTIVE: The objective of the project is to develop and implement simplified method of quickly evaluating the radar signature of a native CAD geometry file.

DESCRIPTION: Many vehicle design concepts require evaluation using the government standard RADAR Cross Section (RCS) prediction model – XPatch. This is often a time consuming process requiring a number of iterations of material assignments, model conversion between computers and lengthy computer runs. A simplified, GUI-based RCS tool is required which will allow direct incorporation of popular PC-based CAD package formats, efficient material assignment and rapid estimation of RCS performance. The tool should also produce XPatch input files for formal RCS evaluation. The focus is on the Pro-E CAD file format, with no change, translation or modification to the native format. The tool must be sufficiently fast to be able to calculate both high and low frequencies(8-100Ghz) interactively at the design station.

PHASE I: The contractor shall design and develop a methodology to interact directly with the CAD geometry to produce cross sections and Inverse Synthetic Apature Radar(ISAR) predictions. The focus is on very fast, rapid turnaround predicitons based on Native CAD/Pro-E Geometry. The prediciton must be performed over X-W bands within sufficient time for the designer to have feedback to his changes. Run times more than an hour will be too long for this process.

PHASE II: The contractor shall extend the methodology from phase I into a prototype capable of demonstrating the full ground combat vehicle system. Validation experiments with turntable measurements provide performance validation. This capability will be integrated with other prediciton tools and geometry configuration tools to provide an end to end development environment for the engineers and scientists. The focus is on rapid turnarounds to provide the engineering team with the nessisary feedback to parametrically design functionallity an stealth into the process. This is critical focus for the Future Combat System(FCS) in that virtually all the desing will be done through virtual design tools like this.

PHASE III: Applications include rapid analysis of features of civilian and non-civilian object to include buildings, vehicles and terrain features. The ability to perform rapid prototyping will be expanded by the integration into larger commercial products being used by industry, Government and academia.

REFERENCES:
References are contained in TRADOC FOC's: TR 97-057 and TR97-043 to 045; and Battlelab FOC's: AR97-203; IN97-100, 160, 210, 220, & 240; MMB97-008, 009, MMB 97-018, MMB 97-020;FA97-003; DSA97-004;EN 97-003; EN 97-030, EN97-103; and MSB97-008.

KEYWORDS: Radar, SAR, ISAR, CAD, RCS, Pro-E, X band, K band, W band.

A01-233 TITLE: Damage Models and Computational Tools for Health Monitoring of Smart Composite Structures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM, SURVIVABILITY

OBJECTIVE: The present research is aimed at developing the theoretical models of damage and efficient computational procedures for analyzing composite laminates with embedded or surface mounted actuating/sensing layers.

DESCRIPTION: Composites have revolutionized structural construction. Present day aerospace and army vehicles, armor, as well as automobiles make use of composite materials extensively. Currently, composites are also used in many building applications and smart highways (i.e. military and civil infrastructure applications). With the availability of functional materials and feasibility of embedding them into or bonding them to composite structures, new smart structural concepts are emerging to be attractive for potentially high-performance structural applications [see Loewy (1997) and Gandhi and Thompson (1992)]. The proposed research is a fundamental study aimed at establishing the feasibility of sensing damage and actuating correcting mechanisms (controls) through the use of embedded smart piezoelectric and magnetostrictive patches.

In developing the damage models, local failure mechanisms and modes may be identified through an appropriate micro-scale model, and subsequent stiffness reduction schemes may be postulated based on the mode of failure. Global-local methodologies at the macro scale may be developed to accurately determine the stress fields so that the damage modes can be predicted realistically. Non-linearities arising from moderately large deflections (but small strains) and non-linear constitutive behavior of smart materials will be accounted for, and efficient computational procedures may be adopted.

The damage evolution models will require multi-scale analysis in which damage at micro and meso scales will be assessed and it will be carried to macro scale in the form of reduced lamina stiffness. Finite element analysis procedures should be developed for local and global scales and their interactions. Shear deformation plate theories as well as the layerwise theories may be used in a multi-model approach that is robust.The main thrust of the research is to develop damage evolution models based on multi-scale analyses as well as finite element analysis procedures for the determination of failure response of laminated composite structures. The computational tools developed herein may be used to study damage detection . The results of this research will contribute to the understanding of the non-linear behavior and damage progression in composite structures. The results will also have a significant impact on the design of composite structures used in light weight composite armor vehicles with a provision for on-line structural health monitoring.

PHASE I: Task-1: Develop the theoretical linear formulation of damage models with multi-scale modeling for analyzing composite laminates with embedded or surface mounted actuating/sensing layers. The damage evolution models will require multi-scale analysis in which damage at micro and meso scales will be assessed and it will be carried to macro scale in the form of reduced lamina stiffness. The proposed approach must be shown to couple with existing analysis tools , such as commercial finite element programs.

Task-2: Formulate the finite element computational methodology based on shear deformation plate theories and incremental solution schemes.

In developing the damage models, local failure mechanisms and modes will be identified through an appropriate micro-scale model, and subsequent stiffness reduction schemes will be postulated based on the mode of failure. Global-local methodologies at the macro scale will be developed to accurately determine the stress fields so that the damage modes can be predicted realistically. Non-linearities arising from moderately large deflections (but small strains) and non-linear constitutive behavior of smart materials will be accounted for, and efficient computational procedures will be adopted.

PHASE II: Task-1: Implementation of the damage and computational methodologies developed in Phase-I into a computer program. Numerical simulations with the developed computer program to study a variety of problems involving smart structural systems and investigate various parametric effects (geometry, lamination scheme, number and location of sensors and actuators, loads, and so on).

Task-2: Numerical studies to demonstrate the sensing feasibility to detect delamination type of defects in laminated composite plate structures.

Task-3 Development of a methodology to adaptively determine the location of the sensor and actuator patches.

Task-4: Theoretical formulation of the layer-wise theory with embedded actuating/sensing layers for the non-linear analysis.

Task-5: Finite element model development and computer implementation of the non-linear formulations. Integration of damage models and nonlinear models.

Task-6: Parametric studies to determine the effect of the number and position of actuators and sensors, and effect of the non-linearity on the stress and vibration response.

PHASE III: The software developed in Phase I and Phase II should be user friendly, have compatibility to apply to commercial structural analysis code and to couple with existing analysis tools , such as commercial finite element programs. The need for a robust damage models and computational tools for health monitoring of smart composite structures exists in both the commercial and military vehicle and aerospace sectors .

The software developed during the first two phases should provide a practical tool for military and commercial designers or manufacturing of composite materials to analyze and design light weight composite vehicles in addition to numerous range of modern applications. The results of this research will contribute to the understanding of the non-linear behavior and damage progression in composite structures. The results will also have a significant impact on the design of composite structures used in light weight composite armor vehicles with a provision for on-line structural health monitoring.

REFERENCES:

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4) Kleinke, D.K., and Unas, H.M.(1994a) "Magnetostrictive Force Sensor", Amer. Inst. Of Physics, Rev. Sci. Instrum, . 64, 1699-1710.

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Kumar, M. and Krishna Murty, A.V. (1999) "Sensing of delaminations in Smart Composite Laminates", J. Aero. Soc. India, 41 (1), pp 7.

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10) Reddy, J. N. and Barbosa, J. I. (2000). ``On Vibration suppression of magnetostrictive Beams", Smart Materials and Structures, to appear.

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13) Maugin, G. A. (1988). Continuum Mechanics of Electromagnetic Solids, North-Holland Series in Applied Mathematics and Mechanics.

14) Newnham, R. E. (1993). ``Ferroelectric sensors and actuators: smart ceramics," in Ferroelectric Ceramics (edited N.~Setter, and E.L.~Colla), 363-380.

15) Uchino, K.(1986).``Electrostrictive Actuators: Materials and Applications," Cer. Bull., 65, 647-652.

KEYWORDS:
Damage Models, Computational Tool, Health Monitoring, Smart Composite Strutures, Smart/ Intelligent Materials

A01-234 TITLE: Ground Vehicle Removable Paint System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM, Future Scout and Cavalry System (FSCS)

OBJECTIVE: The objective of the project is to develop a removable paint system.

DESCRIPTION: There is a military and commercial need for easily removable paint. Combat vehicles have relied on camouflage paint to reduce the detectability for decades. These patterns have been developed for specific regions and environments. The problem is that seasonal changes can significantly effect the performance of these camouflage patterns. In addition, the new Army vision is that we will need to be rapidly deployable to any of a number of theatres. There are many technical challenges to overcome, but there is a severe need for rapid application-rapid removable paint system. A paint that was non-toxic (in application and removal), had low Volatile Organic Compounds (VOCs), was easy to apply in a short period of time, was durable for normal wear and tear, but would be easily removable by soldiers in the field (requiring no special solvents), would be a commercial success as well. Paint removal for the average consumer is at best a detested task. A system that would make paint removal easy would be a breakthrough in the commercial market. At a minimum, the temporary signage, seasonal decoration, and craft markets are just a few of the commercial markets that would benefit from this type of paint system. This removable paint or paint system must be environmentally friendly so special facilities are not needed to capture the residual material. The visual, near infrared, and thermal emissivity characteristics of the removable paint system must also be considered in the evaluation of potential paint components (including binders) and field performance.

PHASE I: The contractor shall design and develop the methodology for the formulation of the Removable Paint System. This shall include the removable binder system, possible paint pigments, paint application methods, and field removal concepts. The development of low VOC and an environmentally friendly paint system and removal system shall be a critical technical goal. Colors of interest include Chemical Agent Resistant Coating (CARC) colors of green, brown, black, tan, and NATO white.

PHASE II: The contractor shall extend the methodology from Phase I into the formulation and demonstration of the Removable Paint System. This would include binder/pigment formulation, paint application, removal, and field test demonstrations. CARC compatibility is desired. Must meet Clean Air Act (including 1990 amendments) standards.

PHASE III: Potential commercial applications will be developed in this phase. In addition to the temporary signage, seasonal decoration, and craft markets, other uses could exist in camouflaging buildings, vehicles, and equipment utilized in parks and recreational areas to maintain a natural seasonal appearance. Other military uses for this technology will also exist in the Navy, Marines, and Air Force.

REFERENCES:

1) "Recent developments in water-reducible chemical agent resistant coatings" ,John A. Escarsega, et al, U.S. Army Research Laboratory, Coatings Research Team, Aberdeen Proving Ground, MD 21005-5066 found at http://www.p2pays.org/ref/05/04367.htm
2) "Low Emissivity Camouflage Coating" , K. G. Chesonis, D. Harris, Army Research Lab., Fort Belvoir, VA. 09/1994, Document ID: DG19990413020117131, NTIS Order No: AD-A286^226/6 ,
3) http://library.northernlight.com/DG19990413020117131.html
4) Clean Air Act plus 1990 Amendments, http://www.epa.gov/oar/caa/contents.html
5) Contained in TRADOC FOC's: TR 97-057 and TR97-043 to 045; and Battlelab FOC's: AR97-203; IN97-100, 160, 210, 220, & 240; MMB97-008, 009, MMB 97-018, MMB 97-020;FA97-003; DSA97-004;EN 97-003; EN 97-030, EN97-103; and MSB97-008. http://www.sarda.army.mil/sard-zt/ASTMP98/astmp98.htm also can register for DTIC sight and use https://ca.dtic.mil/dstp/addition/add.htm.

KEYWORDS: Paint, Advanced materials, Signature Management, Visual Signature, Near Infrared signature, Thermal Management

A01-235 TITLE: Standardization within the Rapid Prototyping (RP) Industry

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM, Light Tactical Vehicles (LTV)

OBJECTIVE: To research, design, prototype and demonstrate an innovative benchmark part that can be created on different rapid prototype machines for the Mobile Parts Hospital (MPH) program.

DESCRIPTION: Traditionally, the rapid prototyping industry has been used to do just that - rapidly make a prototype part to test for form and fit. Recent advancements have added the ability to test function, as well. In fact, the technology has advanced to such a degree, that the RP user community now has its' eye on using RP machines to manufacture low-volume production parts. In order for that to happen, though, standards have to be introduced to ensure that quality objectives can be met.

Small, company-specific efforts at standardization have been undertaken throughout the RP user community (Reference #1) and within academic laboratories, but nothing has been done at a macro level to develop standards for everyone to measure against (Reference #2). Much of the data that does exist within companies and at universities will be assimilated and used to produce a benchmark part (or parts) that is process and material independent that the industry can use to test their machine against (Reference #3).

PHASE I: The contractor shall research and design a benchmark part for the Mobile Parts Hospital program that will allow the rapid prototyping machines on board to quickly and precisely be tested for accurate calibration. This phase will involve determining what previous work on benchmarking RP processes has been done and locating any publications, and obtaining and analyzing previous STL files (special Computer-Aided Design (CAD)/ Computer-Aided Manufacture (CAM) files) or detailed drawings on the above mentioned parts (Reference #4).

PHASE II: The contractor shall extend the research in Phase I to accommodate the mobility requirement of the MPH program and demonstrate the accuracy of the benchmark part in our mobile environment. This will require the development of an analytical model of the RP process to cross reference against the geometry of the test part. The contractor shall also verify this analytical model.

PHASE III: In order for RP machines to be used for low-rate-of-production parts, consistency and quality must be improved. These same features must be improved in order for the MPH program to move from providing a repair part to a vehicle to providing a qualified replacement part. This Phase will commercialize the work done in Phase I and II by gaining industry-wide acceptance through organizations like National Institute of Standards & Technology (NIST) and the American Society for Testing and Materials (ASTM) (Reference #5). There is also potential within the international RP community for research into a benchmark part that is process and material independent.

DUAL USE APPLICATION: The research proposed will have significant impact on the RP community in the manufacturing industry. Standardization of RP processes will help the Army meet it's goals of rapid repair parts provided near the point of need, thereby reducing the logistics burden. Standardization will help the manufacturing industry by enabling RP machines to be used for production parts because quality standards can now be met. It's a win-win situation, leveraging work already done in industry, and applying it for military needs.

REFERENCES:
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2) Rapid Prototyping and 3D CAD systems: The Need for benchmark support based on case studies, Ian Gibson, Steven R. Hanekroot, Proc. Int. Symposium on Automotive Technology and Automation (ISATA), Dedicated Conf. on Rapid Prototyping for the Automotive Industries, Stuttgart, Germany pp34-42, 1995.
3) Benchmarking Various Methods of Layered manufacturing Systems in Rapid Prototyping, K. Loose, T. Nakagawa, RIKEN, 1999.
4) 2000 Benchmarking Rapid Prototyping Technology/ Process and Assessing its Impact on New Product Development Performance, http://rpmi.marc.gatech.edu/project/description/benchmarking.html
5) 1996 The Future of Rapid Prototyping Standards for the Rapid Prototyping Industry, Kevin K. Jurrens, Mechanical Engineer, National Institute of Standards and Technology (NIST).

KEYWORDS: rapid prototyping, Mobile Parts Hospital, standardization, RP

A01-236 TITLE: Engine Dust Detector Development for the M1 Abrams/Crusader

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PM M1 Abrams & Crusader Combat Vehicle

OBJECTIVE: The objective will be to design and develop a real time engine intake air dust detector for application to M1 Abrams/Crusader combat vehicles. The dust detector will be specially tailored for the power pack of the M1 Abrams/Crusader. With the potential of increase use of turbine engines for M1 Abrams/Crusader, the Army Oil Analysis Program (AOAP) may not provide an early enough warning for a malfunctioning air cleaner system. High horsepower engines used in combat vehicles such as M1 Abrams/Crusader are expensive and cannot afford to be damaged by an undetected faulty air cleaner system. The new design dust detector system will give the driver a warning when specified dust particle concentrations and particle sizes could damage the internal parts of an engine.

DESCRIPTION: Past and present dust detector technology will be studied and evaluated to determine present state-of-the-art application and limitations. These findings will determine the applied research, advanced technology and development efforts needed for application to military combat vehicles and their particular environments and operating requirements. A new low cost prototype engine dust detector specially tailored for M1 Abrams/Crusader will be designed, developed and tested. The M1 Abrams/Crusader has a new power package program and implementation of a dust detector design at an early phase of the program will increase chances of success.

The dust detector program will aim at determining dust particle concentrations, micron sizes and particle shapes harmful to engines. Prototype dust detectors will be designed, built and lab tested to verify performance and requirements of dust detector as well as verify repeatability, reliability and durability.

PHASE I: Research current/past dust detector technology as it relates to engine application for M1 Abrams/Crusader. Determine critical dust particle concentrations, micron sizes and particle shapes harmful to engine applications. Conduct trade-off studies and determine requirements needed for engine application to the power package configuration for M1 Abrams/Crusader. Design and develop a dust detector concept working model for the use in M1/Cruaser power pack. Provide concept drawings showing the feasibility of the design approach.

PHASE II: Develop and demonstrate a breadboard prototype dust detector in a realistic environment. This will include dust tests at dust concentrations up to 20 times zero dust visibility. Following initial testing, determine engineering design changes needed for an enhanced hardware prototype dust detector. Verify through lab testing that real time dust detector can verify and detect critical dust particle concentrations micron sizes and particle shapes harmful to M1 Abrams/Crusader engine. Conduct additional dust and environmental tests to assure prototype dust detector can meet stringent operational requirements of power package configuration for M1 Abrams/Crusader combat vehicles.

Conduct tests to harden the design and to prove feasibility over extended operating conditions and to prove dust detector reliability and repeatability.

PHASE III: The dust detector could be used in a broad range of military ground vehicles using various type engines and commercial off road equipment and mining applications where heavy dust conditions exist. The new state-of-the-art real time dust detector could replace existing non real time commercial dust detector application.

REFERENCES:
1) TARDEC Technical Report No. 13529, TITLED: Engine Intake Air Dust Detector Requirements and Performance, DATED: March 1991, Contractor: Southwest Research Institute (SwRI).
2) TARDEC Technical Report No. 13514, TITLED: Engine Intake Air Dust Detector (U) Phase II, Small Business Innovative Research (SBIR), Contract No. DAAE07-89-C-R011, DATED: November 1990, Contractor: TSI Incorporated.

KEYWORDS: Dust detector, internal combustion engines, real time dust detector, dust concentration, particle size, dust particle shape, dust particle micron size.

A01-237 TITLE: Macro Scale Portable Bi-directional Reflectance Distribution Function (BRDF) Instrumentation

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Scout and Cavalry System (FSCS)

OBJECTIVE: The objective of the project is to develop Bi-directional reflectometer capable of measuring large scale vehicle and background terrain reflectances for use in combat vehicle signature analysis.

DESCRIPTION: Radiometric signature simulations for evaluating ground targets in natural environments require an accurate Bi-directional Reflectance Distribution Function (BRDF) characterization materials in the visible through thermal infrared spectral bands. Traditional laboratory and field BRDF measurement systems employ small aperture illumination optics with small (< ~1 inch) spot sizes on the sample and measure only the small scale BRDF characteristics. Many natural and man-made objects (e.g. rocks, tree bark, and 3-D surface treatments) have surface features larger than this dimension, which leads unreliable measurements of the BRDF characteristics. There therefore, a military need to develop a BRDF instrument that is field portable with a large (~6 inch) measurement spot size to measure large-scale BRDF effects. Considerable basic research and technical innovation will be required to develop the necessary object illumination sources, reflectance sensors, and data processing capabilities for this device. These technical barriers are the reasons that commercial development of this measurement capability has not been achieved previously. This measurement instrument would have commercial applications in the Computer Aided Design (CAD), simulation, and computer visualization communities. The large-scale BRDF measurements would improve the realism of computer visualizations in many areas of the commercial sector.

PHASE I: The contractor shall design and develop the methodology and overall hardware concept for a field measurement device. This device would measure the BRDF of large scale surface structures with at least a 6 inch spot size. Methods for allowing variable spot size measurements shall be examined with trades of performance and device complexity. This phase shall include selection of possible object illumination and reflectance sensor components for the device. Overall technical feasibility of the concept BRDF system shall be determined.

PHASE II: The contractor shall develop an engineering prototype which demonstrates the BRDF measurement capabilities of the Phase I concept. Following prototype fabrications, validation experiments with well characterized BRDF reflectance coatings shall determine the basic performance of the engineering prototype. Following these validation measurements, small scale structures shall be measured and compared with well characterized predicted results. Filed testing of more complex natural and man-made objects will then demonstrate the field utility of the prototype. An important capability for demonstration is the time required to measure anisotropic surfaces in a field test environment.

PHASE III: Dual use applications consist of commercial market architectural surface renderings, hyperspectral geological characterization. The lighting diffusion market is also in need of these types of instruments for light distribution systems for commercial applications.

REFERENCES:
Principles of Optics, Born and Wolf, Pergamon press.

KEYWORDS: Bi-Directional Reflectance Distribution Function, Laboratory Measurements, Optics, Thermal, Visual, Computer Rendering.

A01-238 TITLE: Removal of Nuclear and Chemical Agents from Water

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PM Petroleum and Water Systems

OBJECTIVE: The objective of this project is to develop a compact, rugged, mobile, energy-efficient technology, adaptable for use with current army mobile reverse osmosis based water purification systems, that will remove and/or destroy nuclear and chemical warfare agents.

DESCRIPTION: The core technology for the military's current water purification systems is reverse osmosis (RO). RO can reduce the concentration of nuclear and chemical agents, however, in order to meet drinking water standards the RO product water must be polished with granular activated carbon or ion exchange depending on the specific agent present. These polishing technologies have a finite and ill-defined capacity for removal of nuclear and chemical agents. Once this capacity has been

reached the military must dispose of the hazardous nuclear or chemically contaminated media. The Army is interested in the development of technology that would provide a more effective treatment for these agents than current GAC and ion exchange. Technologies of interest would have an advantage over the current technologies such as, a higher capacity, the ability to treat both nuclear and chemical agents with a single technology, or the ability to be regenerated, if necessary, in the field. Preferable to technologies that merely sequesters or changes the phase in which the contaminant occurs (adsorption) would be a technology that converts the target agent into a benign product, thus eliminating the need to dispose of a hazardous waste. The technology must be adaptable for use with the current military systems, compact, lightweight and energy efficient. For comparative purposes the current 600 gallon per hour system treatment system is approximately 14.5 cubic feet for 100 hours of operation before replacement is required.

PHASE I: Demonstrate the feasibility of the technology to remove nuclear and chemical agents from water through analysis/modeling and testing in a laboratory environment. Analyze the results to provide a measure of effectiveness, capacity, kinetics, etc.

PHASE II: Develop and test a prototype system for the removal of nuclear and chemical agents from water. The test protocol should be adequate to test the performance, durability, and capacity of the technology. This data should provide sufficient information for the design of a full-scale system including sizing and system run life. Use the results of the prototype testing to design devices for current army water purification devices.

PHASE III: These devices would have a broad range of military and civilian applications where contamination of water sources is a concern. This includes all army water purification systems and may be applicable to emergency response agencies, agencies responsible for countering terrorist threats, and organizations that operate in unstable regions. Potential technologies may also be effective against pesticides and herbicides found in water sources and therefore, are of interest to municipal water treatment organizations and homeowners in regions where this type of contamination has been identified.

REFERENCES:
1) Bagwell T.H., Shalewitz B., and Coleman A., "The Army water supply program: An overview," Desalination, v99, p409-421, 1994
2) Directorate of Combat Developments for Quartermaster (DCDQM), www.cascom.lee.army.mil/quartermaster
3) FM 10-52, Water Supply In Theaters of Operation, 1990 (see DCDQM website)
4) FM 10-52-1 Water Supply Point Equipment and Operations, 1991 (see DCDQM website)
5) U.S. Army Functional Concept For Potable Water Support (see DCDQM website)
6) Potable Water Planning Guide, 1999 (see DCDQM website)
7) U.S. Army Center For Health Promotion and Preventative Medicine (CHPPM), http://chppm-www.apgea.army.mil
8) TB Med 577, Sanitary Control and Surveillance of Field Water Supplies (see CHPPM website)
9) TRADOC Pam 525-66, Future Operational Capability, 1997, 1999, FOC QM97-003, QM99-003, (www.tradoc.army.mil)

KEYWORDS: Water Purification, nuclear and chemical agent removal

A01-239 TITLE: Advanced Propulsion System Heat Management Optimization

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PM, Heavy Tactical Vehicles

OBJECTIVE: Improve fuel economy, reduce emissions and improve reliability of vehicular engines by development of a standard heat management analysis methodology and optimization of the cooling system through application of advanced or non-traditional technology/components, such as increased engine operational temperatures and electrical pumps.

DESCRIPTION: Develop a scientific and systematic approach for the identification and correction of excessive internal engine metal temperatures that may lead to early engine failure. Apply state of the art cooling system components and products to correct deficiencies and to determine applicability/desirability of operating engines at higher temperatures and of utilizing electrical pumps.

PHASE I: Conduct a baseline propulsion system heat profile analysis to: a) Determine the applicability/desirability of increasing the engine operational temperatures; as a minimum, define/determine the interrelationships between, and the effects on, the engine oil, fuel, coolant systems and associated seals, the air/aerodynamic and EGR systems, the involved electronic controls, and the engine performance by operating the engine at increased temperatures. b) Determine/define engine operational temperature limits for operations at increased engine temperatures. c) Determine the effect on engine performance and the engine

cooling system by introduction of electrical pumps into the system. d) Determine the feasibility of eliminating the engine cooling fan, of eliminating the radiator cap, or the substitution of a low pressure cap, of eliminating the coolant bypass system, and of utilizing smaller heat exchangers (radiators) and associated hardware.
Results of the analysis will be presented in a report, along with all the data and suggested potential heat management improvement strategies to be developed and investigated in Phase II.

PHASE II: Implement a selected set of technologies from Phase I and verify the validity of the selection through engine test cell testing and on vehicle testing (such as an M1070 HET or an FMTV vehicle) in the military environments. Data will, also, be gathered with concurrent system optimization/component maturation. If required, an improved cooling system for the tested engine will be configured and retested/validated, as above. A Phase II report will describe a validated systematic process for cooling system optimization that can be applied across vehicle/truck platforms. The heat management analysis processes and components developed will then be implemented on a small fleet of selected commercial and military trucks.

PHASE III: The process and components developed in this SBIR, if retrofitted to existing commercial and military engines could be used to enhance their performance and reliability. Additionally, these products could also insure that future 'clean sheet' engine designs, optimized from a cooling system perspective, would benefit substantially in areas of increased mileage and reduced emissions.

REFERENCES:
1) GM, 6.2 L IDI Engine Heat Rejection Comparison, 1984.
2) Army, 6.2L HMMWV Engine Improvement Program, 1998-Current
3) SwRI test, Non-aqueous Propylene Glycol Coolant in 6.2L Engine

KEYWORDS: NPG, Non-aqueous Propylene Glycol, electric pumps, impeller, parasitic losses, high temperature lubricants, EGR cooling, heat management.

NAVY
PROPOSAL SUBMISSION
INTRODUCTION

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper, (703) 696-8528. The Deputy SBIR Program Manager is Mr. John Williams, (703) 696-0342. If you have any questions of a specific nature, you may contact one of the above persons. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-216-4095. For technical questions about the topic, contact the Topic Authors listed on the website on or before 1 July 2001.

The Navy's SBIR program is a mission-oriented program that integrates the needs and requirements of the Navy's Fleet through R&D topics that have dual-use potential. Information on the Navy SBIR Program can be found on the Navy SBIR website at **http://www.onr.navy.mil/sbir.** Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the website at **http://www.navy.mil.**

Note: Also see additional Navy Topics listed in the Addendum in the back of this Solicitation

PHASE I PROPOSAL SUBMISSION:

When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I should be 6 months and for the Phase I option should be 3 months. The Phase I option should address the transition into the Phase II effort and should be the initiation of the next phase of the SBIR project (i.e. initial part of Phase II). Phase I proposals, including the option, have a 25-page limit (see section 3.3). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. For technical questions about the topic, contact the Topic Authors listed on the website on or before **1 July 2001**. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

It is mandatory that a DoD Proposal Cover Sheet and the Company Commercialization Report are submitted electronically through the DoD SBIR website at **http://www.dodsbir.net/submission**. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-866-216-4095.

NEW! OPTIONAL ELECTRONIC SUBMISSION OF TECHNICAL PROPOSALS

For this solicitation, companies will have **two** options for submission of proposals to the Navy:

Option 1 -All Electronic Proposal Submission:
Complete electronic submission which will include the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, and the **entire** technical proposal including all forms via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. If you choose to submit your technical proposal electronically, it must be submitted online on or before the **3:00 pm EST, 15 August 2001 deadline,** but a hardcopy will not be required at this time. *Acceptable Formats for Online Submission:* All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes; therefore, submissions may be received in PDF format but other acceptable formats (PC/Windows) are MS Word, WordPerfect, Text, Rich Text Format (RTF), and Adobe Acrobat. The Technical Proposal should include all graphics and attachments and should conform to the limitations on margins and number of pages specified in the front section of this DoD Solicitation. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in downloading your Technical Proposal.

Option 2 -Paper Submission of Proposal and Electronic Submission of Cover Sheets and Company Commercialization Report:
Hardcopy submission of Technical Proposal **and** electronic submission of Cover Sheets and Company Commercialization Report through the DoD proposal submission site, http://www.dodsbir.net/submission. You must print out the forms directly from this web site, sign the forms, and submit them with your hardcopy proposal. The format of your hardcopy proposal should be: Proposal Cover Sheet Pages (signed), Technical Proposal and Option (25-page limit), Cost Proposal (signed), and Company

Commercialization Report (signed). **For Option 2 you must mail one original and four copies of your Phase I proposal to the address below. Proposals must be received by 15 August 2001.**

U.S Mail packages send to:	Overnight Mail Services or Courier packages send to:
Office of Naval Research ONR 364 SBIR Ballston Tower #2, Room 106 800 North Quincy Street Arlington, VA 22217-5660	Office of Naval Research ONR 364 SBIR Ballston Tower #2, Room 106 801 North Randolph Street Arlington, VA 22203

PHASE I ELECTRONIC FINAL REPORT:

All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results and should include potential applications and benefits and not exceed 700 words. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR Website at: **http://www.onr.navy.mil/sbir**, click on "Submission", then click on "Submit a Phase I or II Summary Report".

ADDITIONAL NOTES:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as subcontractors in the SBIR/STTR program, since they are institutions of higher learning.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir.** A Navy success story is any follow-on funds that the firm has received from a past Phase II Navy SBIR or STTR award. The success story should then be printed and included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report (formerly Appendix E) and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR Phase II it will not count against them. Phase III efforts should also be reported to the Navy SBIR program office noted above.

NAVY FAST TRACK DATES AND REQUIREMENTS:

The Fast Track application must be received by the Navy 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the Navy SBIR Program Manager at the address listed above, to the designated Contracting Officers Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Navy Activity SBIR Program Manager listed in Table 1 of this Introduction. The information required by the Navy is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

PHASE II PROPOSAL SUBMISSION:

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been **invited** to submit a Phase II proposal by that Activity's proper point of contact, listed in Table 1, during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award. If you have been invited to submit a Phase II proposal to the Navy, obtain a copy of the Phase II instructions from the Navy SBIR website or request the instructions from the Navy Activity POC listed in Table 1. The Navy will also offer a "fast track" into Phase II to those companies that successfully obtain third party cash partnership funds ("Fast Track" is described in Section 4.5 of this solicitation). The Navy typically provides a cost plus fixed fee contract or an Other Transition Agreement (OTA) as a Phase II award. The type of award is at the discretion of the contracting officer.

Upon receiving an invitation, submission of a Phase II proposal should consist of three elements: 1) a $600,000 base effort, which is the demonstration phase of the SBIR project; 2) a separate 2 to 5 page Transition/Marketing plan (formerly called a

"commercialization plan") describing how, to whom and at what stage you will market/transition your technology to the government, government prime contractor, and/or private sector; and 3) at least one Phase II Option ($150,000) which would be a fully costed and well defined section describing a test and evaluation plan or further R&D if the Transition/Marketing plan is evaluated as being successful. Phase II efforts are typically two (2) years and Phase II options are typically an additional six (6) months. Some Navy Activities have different schedules and award amounts; you are required to get specific guidance from them before submitting your Phase II proposal. Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). The Transition/Marketing plan must be a separate document that is submitted through the Navy SBIR website under "Submission" and included with the proposal hard copy. All Phase II proposals must have a Proposal Cover Sheet and Company Commercialization Report submitted through the DoD SBIR website at **http://www.dodsbir.net/submission** and Transition/Marketing plan submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir.**

All Phase II award winners must attend a two day Commercialization Assistance/Business Plan Development Course from the Navy. This is typically taken at the beginning of the 2nd year of the Phase II. If you receive a Phase II award, you will be contacted with more information regarding this program.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary report through the Navy SBIR website at the end of their Phase II. The Phase II Summary Report is a non-proprietary summary of Phase II results and should include potential applications and benefits and not exceed 700 words. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR Website at: **http://www.onr.navy.mil/sbir,** click on "Submission", then click on "Submit a Phase I or II Summary Report".

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy SBIR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional SBIR funds can be provided as long as the Phase III is awarded and funded during the Phase II. If you have questions, please contact the Navy Activity POC.

Effective in Fiscal Year 2000, a Navy activity will not issue a Navy SBIR Phase II award to a company when the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy SBIR Program Office. Also, any SBIR Phase I contract that has been extended by a no cost extension beyond one (1) year will be ineligible for a Navy SBIR Phase II award using SBIR funds.

TABLE 1. NAVY ACTIVITY SBIR PROGRAM MANAGERS POINTS OF CONTACT (POC) FOR TOPICS
Note: Also see additional Navy Topics listed in the Addendum in the back of this Solicitation

Topic Numbers	Point of Contact	Activity	Phone
N01-108 to N01-112	Mr. Rod Manzano	MARCOR	703-784-1395
N01-113 to N01-130	Mr. Bill Degentesh	NAVSEA	202-781-3740
N01-131 to N01-149	Mr. Douglas Harry	ONR	703-696-4286
N01-150 to N01-152	Ms. Susan Schneck	NAVSUP	717-605-1305
N01-153 to N01-183	Ms. Carol Van Wyk	NAVAIR	301-342-0215

Do not contact the Program Managers for technical questions. For technical questions, please contact the topic authors during the pre-solicitation period from 1 May 2001 until 1 July 2001. These topic authors are listed on the Navy website under "Solicitation" or the DoD website. After 1 July, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website for more information.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. The DoD Proposal Cover Sheet and the DoD Company Commercialization Report have been submitted electronically through the DoD submission site.

____2. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

____3. Submission:
Option 1) Cover Sheets, Company Commercialization Report, and Technical Proposal have been submitted online on or before 15 August 2001.
Option 2) Cover Sheets and Company Commercialization Report (submitted online) and an original and 4 copies of the entire PH I proposal must be received on or before 15 August 2001 at the address above. The Navy will not accept late or incomplete proposals.

NAVY 01.2 SBIR TITLE INDEX

Marine Corps Systems Command (MARCORP)

N01-108	Through the Wall Sensor
N01-109	Ti:Sapphire Hybrid Laser
N01-110	Non-Intrusive, Window Mounted, Conformal Antennas
N01-111	Wireless Radio Frequency Communication Link for Small Unmanned Ground Vehicles
N01-112	Internal Periscope Displays for Embedded Training

Naval Sea Systems Command (NAVSEA)

N01-113	Shipboard SMART Foundation Adapter
N01-114	Automated Shipboard Food Service
N01-115	Hn System Integration Rapid Analysis Tool for Evaluation of System Concepts Early in Development
N01-116	Embedded Training in an Optimized Manning Environment
N01-117	Non-Lethal Ship Defense Response Systems (Anti-surface)
N01-118	Surveillance of Ship Security Perimeter While in Port
N01-119	Simulation Environment in Support of Non-Cooperative Target Recognition (NCTR) Algorithm Development
N01-120	Global Positioning System (GPS) Jamming Situational Awareness for Naval Surface Fire Support (NSFS)
N01-121	Non-GPS Projectile Navigation
N01-122	Modeling High-Temperature Erosive Gas Flow to Support Barrel Erosion Reduction Concept Modeling for Fire Support Gun Application
N01-123	Wireless Audio/Video Headsets
N01-124	Advanced Power Distribution Systems
N01-125	Scale Prevention in Seawater and Freshwater Flushed Shipboard Sanitary Waste Systems
N01-126	Advanced Treatment Technology for Shipboard Non-Oily Wastewater
N01-127	Tactical Sonar Data Fusion
N01-128	Novel Approaches for Automated Information Processing of Active Sonar Data
N01-129	Thermal Stress Management of Infrared (IR) Windows
N01-130	Integrated Underwater Sensing System for Platform Safety & Threat Alertment

Office of Naval Research (ONR)

N01-131	Multiple-Beam Electron Gun for High Power Amplifiers
N01-132	Low-cost. Lightweight, Mid-Wave InfraRed (MWIR) Sensors
N01-133	Maritime Intelligence, Surveillance, Reconnaissance (ISR) and Space Exploitation
N01-134	Component Level, Multimedia communication technology for survivability
N01-135	Boost-Phase Sub-Unit Vaccine Development for Binary Vaccines Against Infectious Diseases and Biological Warfare Agents
N01-136	Digital Cellular-Phone Transceiver-based Foliage Penetration Interferometric SAR for EO/IR Sensor Fusion ATR
N01-137	Expeditionary Logistics
N01-138	A Self-Contained Solar Radiation Measurement Package for an Aircraft
N01-139	Smart Low Altitude Platform for Atmospheric Measurements from a Research Aircraft
N01-140	Conductive Carbon Nanotubes for EMI Shielding of Naval Aviation Optical Materials
N01-141	Portable Emissivity / Reflectometer for Measurements on Curved Surfaces
N01-142	Rapid RF Switching Conducting Polymers
N01-143	Compact, Digital Man-Portable Infrared (IR) Measurement Device
N01-144	Small Diesel Engines, JP5 / JP8 Fueled
N01-145	Very Low Cost, Lightweight Detector Technologies for Small, Expendable Unmanned Air Vehicles (UAVs)
N01-146	Airframe Construction for Small, Expendable Unmanned Air Vehicles (UAVs)
N01-147	Very Low Cost Unmanned Air Vehicle (UAV) Avionics
N01-148	Very Low Cost, Lightweight IridiumTM / GlobalstarTM Communications Modules
N01-149	Expendable Active Battle Damage Assessment Sensors

Naval Supply Systems Command (NAVSUP)

N01-150 Technology for Logistics Productivity
N01-151 Laboratory Convective / Steam Heat Test Apparatus
N01-152 Environmentally Friendly Advanced Food Packaging

Naval Air Systems Command (NAVAIR)

N01-153 Low Volatile Organic Content (VOC) Solid Film Lubricant
N01-154 Probabilistic Mission/Engine Duty Cycle Analysis
N01-155 Coupled Vertical/Short Takeoff and Landing (VSTOL) Down Wash-Ground Effect and Ship Air Wake Turbulent Flow Simulation Model
N01-156 Nonlinear Combustion Stability Prediction of Solid Rocket Motors
N01-157 Transparent, Electrically Conductive Coatings for Infrared Windows
N01-158 Enhanced Propeller Visibility
N01-159 Material Encoded Textures with Computer Generated Forces (CGF)
N01-160 Aluminum Honeycomb Panel/Substructure Replacement Initiative
N01-161 Active and Passive Reduction of Noise Caused by Bone Conduction to the Head of U.S. Navy Deck Crew Personnel with Helmets
N01-162 Active Noise Reduction Earplug and Improved Speech Intelligibility for Aircrew and Deck Crew Personnel with Helmet Integrated Communication Systems
N01-163 High-Voltage Cables and Connector
N01-164 Fiber Optic Cables and Connectors
N01-165 Corrosion/Erosion Resistant Coatings for Turbine Compression Systems
N01-166 Multi-Channel Electronic Scanning Module for an Ultrahigh Frequency (UHF) Circular Array
N01-167 Fuel Reformulation to Reduce Contaminants
N01-168 Thin Layered Damping Treatments for Turbo Machinery
N01-169 Non-Mechanical Beam Steering for Infrared Countermeasure (IRCM) Applications
N01-170 New Cooling Technology to Increase Aircraft Generators Power Rating
N01-171 Visualization and Quantification System for Modeling Unsteady Aerodynamics for Aircraft Simulations
N01-172 New Mid-Infrared (IR) Laser Materials
N01-173 Non-Explosive Broadband Acoustic Source for Multi-Static Anti-Submarine Warfare (ASW)
N01-174 Wireless Leave-In-Place Aircraft Structural Nondestructive Evaluation (NDE) Sensors
N01-175 CODEC (Code/Decode) for Digital Buoys in a Harsh RF Environment
N01-176 Fiber Optic Ethernet for Aviation Intercommunications System Voice Transmission
N01-177 Hydraulic Seal Replacement
N01-178 Photonic Switching for Aircraft Fiber Optic Networks
N01-179 Low-Cost Dual-Mode (Visible/Infrared) Imager
N01-180 Low-Cost Global Positioning System (GPS) Oscillator
N01-181 Automated Strike Package Planning System
N01-182 Advanced Modeling to Characterize Failure Progression Rates from the Incipient Stage to Component Failure
N01-183 High-Temperature/Lower Cost Appliqué Material

NAVY 01.2 SBIR WORD/PHRASE INDEX

A

B

C

Marine Corps Systems Command (MARCORP)

N01-108 TITLE: Through the Wall Sensor

TECHNOLOGY AREAS: Sensors, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV (T): Clear Facilities

OBJECTIVE: This topic seeks to develop an advanced sensor system or system of systems that will provide a capability for the clandestine determination of the location, armament, and other tactical information on personnel and equipment/materiel through a wall from a remote location.

DESCRIPTION: The Marine Corps needs a capability to sense/determine the location, armament, and other tactical information on personnel and equipment/materiel through a wall from a remote location. The system can be continuous, intermittent, or utilize an active initiator system like radar. The minimum range required is from the outside wall of the target building or the surface of the ground outside an underground location. It is desired that the system work at as long a range and through as many types of construction materials as possible including caves, tunnels, or underground bunkers. It is not essential that one technology work through all possible materials. The range desired is 100 meters from the outside wall of the target building or the surface of the ground outside an underground location. A sensor that will work from the outside surface of the building or the ground for underground structures would be the absolute minimum capability. The system needs to be clandestine, i.e. setting off explosions and reading reflected sound waves like the systems used for oil exploration would not be acceptable.

PHASE I: Determine insofar as possible the scientific, technical, and commercial merit and feasibility of a system or system of systems to provide the desired capability. Develop the technology with brassboard models of the critical components that demonstrates the applicability to infrared, electromagnetic, directed energy, acoustic or any other detectable or producible signatures. Perform a demonstration of the developed model by the end of this phase. Provide an estimate of the cost, schedule, technical performance and risk of the demonstrated capabilities.

PHASE II: Build prototypes of the model from Phase I. The prototypes shall be produced to best commercial practices. If additional commercially available technologies are required to address additional materials of construction or increased range, provide a demonstration of the total system. Develop a commercial marketing plan for the system.

PHASE III: Further develop the system for both commercial and military applications. The resultant system shall be made commercially available by the close of Phase III.

COMMERCIAL POTENTIAL: Military, fire & rescue, and law enforcement organizations have a need to determine the location of people and material inside of buildings.

REFERENCES:

1. There are no fielded capabilities in the military. Several companies have indicated that there is some capability but either the display of information requires an engineer to interpret or there are too few materials that can be seen through to make it feasible
2. Mission Need Statement for Clear Facilities Reference number, LOG 1.85, 02/20/96

KEYWORDS: Remote sensors, Sensors, Acoustic Technology, Lasers, Directed energy

N01-109 TITLE: Ti:Sapphire Hybrid Laser

TECHNOLOGY AREAS: Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: COBRA- ACAT (IV)

OBJECTIVE: Develop a multi-wavelength Hybrid Ti:Sapphire/Nd:YAG laser system with high output pulse energy and the ability to achieve five simultaneous output wavelengths to accomplish active multispectral aerial reconnaissance.

DESCRIPTION: Recent program success under the Joint Mine Detection Technology program has produced a hybrid design laser capable of operating at four simultaneous wavelengths (Ref. 1,2). Due to certain materials properties in the Cr:LiSaf portion of the device power is limited in two of the wavelengths. A better design with higher power, a possible extra 5th wavelength, tunability across a portion of the spectrum, and a more compact design could be obtained through a design around a Ti:Sapphire/Nd:YAG laser. This newer hybrid laser would provide more output power and extra wavelength capability. Diode

pumping offers the possibility of a more compact design and tuning expands operational range. Recent developments in pump lasers and Sapphire quality show promise to allow for hundred plus millijoule energy per pulse output. Current military reconnaissance programs could greatly benefit from the simultaneous active multi-wavelength imaging capability of this hardware. The range-gated capability of the multi-wavelength device will allow imaging systems to penetrate obscurants and water. The high power energy will ensure optimum capability to penetrate obscurants while providing plenty of photons for night time imaging. Selected invisible wavelengths could be used for clandestine night time imaging.

PHASE I: Investigate enabling technologies and component designs and relate the results to a hybrid laser system design capable of providing five simultaneous wavelength outputs at high energy per pulse to provide sufficient illumination for night time and through the water imaging while maintaining compactness and modularity. Consider diode pumping, tunability, and polarization capability to enhance system design. Provide details into possible prototype designs and use modeling, analysis, empirical testing or construction of risk reduction parts or sub assemblies to ensure optimum path. The results of the investigation must include a technology optimization path and system design that will provide a guide to Phase II activity.

PHASE II: Utilize the findings established in Phase I to design, develop, construct, test, and deliver a functional fieldable system prototype of the enabling technology which can be applied, with matched specifications, to support a variety of sensor systems. System functionality, capability, flexibility, and usability should be maximized for aerial reconnaissance.

PHASE III: Advancement in compact and modular illumination systems can serve both the civilian and military needs. Common application needs include navigation, law enforcement, security systems, hazardous environment monitoring, and surveillance. Additional military applications include reconnaissance, targeting, IFF, guidance, and other overt/covert operations support.

COMMERCIAL POTENTIAL: This system could provide useful information to a variety of industry areas including remote sensing, biomedical imaging, environmental and agricultural monitoring, pollution monitoring, navigation, and law enforcement,

REFERENCES:

1. Holloway, Xybion Electronic Systems Corporation, “Multispectral Hybrid Laser Phase II Test Plan for Laboratory and Field Measurements”, Apr 99
2. Lin, Andriasyan, Swatrtz, Witherspoon, Holloway, “Multiwavelength output from a Nd:YAG/Cr:LiSAF hybrid laser”, Applied Optics, Vol 38, No. 9, Mar 99.
3. Witherspoon, Holloway, "Feasibility Testing of a range-gated laser illuminated underwater imaging system," Proceeding of the International Society for Optical Engineering, Vol 1302, Ocean Optics X, April 1990, pp 414-420.
4. Witherspoon, Holloway, et. al., "Measured Degradation in Image Quality When Imaging Through A Wavy Air-Water Interface, Proceedings of the Society of Photo-Optical Instrumentation Engineers, Ocean Optics IX, April 1988.
5. Witherspoon, Holloway, et. al., "Experimentally Measured MTF's Associated with Imaging Through Turbid Water," Proceedings of the Society of Photo-Optical Instrumentation Engineers, Ocean Optics IX, April 1988.
6. Holloway, Lorenzo, Pham, "Gated Laser Video Sensor (GLVS) Large Area Smoke Experiment (LASEX) Report," NCSC Report, Oct 94
7. Holloway, "Gated Laser Video Sensor Smoke Week Test Plan," NCSC Report, April 94
8. Witherspoon, Holloway, et. al., "Experimental Results of Single Pulse Imaging Through Turbid Water of up to 2 Meter Depth Using a Blue-Green Short Pulse Width Laser and a CID Gated Array Camera System." NCSC Technical Report.
9. Blume, "Enhancement of the Gated Laser Video Sensor Image Synthesis Tool - Final Report,"
10. Blume, "Gated Laser Video Sensor Image Synthesis Tool Simplified Model - Final Report," Oct 94
11. Blume, "Gated Laser Video Sensor Image Synthesis Tool Simplified Model - Users Manual," Oct 94

KEYWORDS: Laser Diode Array, Diode Array, LADAR, Range Gating, Gated Imaging, Laser Radar

N01-110 TITLE: Non-Intrusive, Window Mounted, Conformal Antennas

TECHNOLOGY AREAS: Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: MARCORSYSCOM PM INTEL

OBJECTIVE: This project will result in allowing signals collection teams to attach a portable wideband membrane antenna to the inside of windows of various platforms. These antennas may be utilized as a single unit or as arrays. This will allow use of any available platform for signal collection without concern for the safety and space requirements encountered with external antennas.

DESCRIPTION: USMC Radio Battalions are required to provide signal collection operations with organic resources. Collection platforms are frequently not available with antennas of characteristics required for frequencies of interest. Thus the Marine is required to utilize any non-dedicated platform (man/team, air, ground, water, etc) and make do with antenna suites that happen to reside on the platform. This program is focused on developing conformal membrane antennas that can be mounted inside the windows of these platforms. The technology utilized for the development of these non-intrusive conformal antennas is fractal antenna design. Fractal antenna design techniques have been studied for antenna application over the past decade and are particularly suited for this application.

PHASE I: Develop a set of performance models and equations to predict and optimize the expected performance of fractal antenna designs of various sizes. Particular emphasis will be placed on determining the optimal fractal membrane structure balancing portability, gain, pattern, and conformal characteristics.

PHASE II: Develop and test a set of engineering development prototype antennas (four 4). This will include measurement of antenna pattern and gain in an antenna range environment. Field testing on candidate platforms will follow the range testing.

PHASE III: Production of antennas for USMC Radio Battalions use.

COMMERCIAL POTENTIAL: The commercial potential of this antenna technology includes furthering the development of the practice of Fractal Antenna Design and a new class of antennas for amateur radio use which may allow 'hams' to enjoy their hobby in city environments where construction of large antenna structures is not allowable.

REFERENCES:
1. Fractal Antenna Engineering: The Theory and Design of Fractal Antenna Arrays. Werner, Douglas H, et al, IEEE antennas & propagation magazine. OCT 01 1999 v 41 n 5 37.
2. On the Behavior of the Sierpinski Multiband Fractal Antenna. Puente-Baliarda, C. et al, IEEE transactions on antennas and propagation. APR 01 1998 v 46 n 4 517.

KEYWORDS: Antennas, Conformal, Fractals, Wideband, Apertures, and Communications

N01-111 TITLE: Wireless Radio Frequency Communication Link for Small Unmanned Ground Vehicles

TECHNOLOGY AREAS: Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III, GLADIATOR Program

OBJECTIVE: Design and build a Wireless Radio Frequency (RF) Communication Link for small Unmanned Ground Vehicles (UGV) to allow them to effectively operate in enclosed spaces such as sewers, tunnels, and buildings without utilizing a physical tether for communications between the operator and the UGV.

DESCRIPTION: Small UGVs have been used in past experiments to conduct tunnel, sewer, and building reconnaissance missions. The purpose of these missions is to use UGVs in place of Marines and Soldiers to locate booby traps such as trip wires, mines, and snipers, thereby removing them from harm's way. These vehicles carry a variety of sensors on-board to allow the UGV to provide situational awareness data to the operator. This information is then forwarded to the battlefield decision makers to allow them to plan their missions to mitigate loss of Marines and Soldiers lives.

The small UGVs currently being utilized to demonstrate these capabilities use commercial off-the-shelf, radio frequency (RF) communications links to transmit information between the operator and UGV. These communication links do not work well in enclosed spaces due to the nature of RF energy propagation. Typically, the UGV will get some distance into the sewer, tunnel, or building and the communications link will drop out, thus disabling the UGV. At this point, the data feedback to the operator is also disabled. This is not an acceptable result or conclusion to the mission.

There are emerging requirements for small UGVs to support Military Operations in Urban Terrain (MOUT), Operations Other Than War (OOTW), and Ship to Objective Maneuver (STOM) operations. This effort will use emerging technologies to design a Wireless RF Communication Link that is optimized for use on small UGVs in these environments. It will incorporate innovative types of modulation and data compression schemes, antenna design techniques, and power management technologies to enhance the propagation characteristics of the RF energy, thus allowing the UGVs to complete their missions.

Successful submissions will propose solutions for short range (100-500m) wireless communication between UGVs and the operator, operating in enclosed spaces such as corridors, ventilation shafts, utility tunnels, sewer pipes, and evacuated water mains. Proposed solutions will also address non-line-of-sight issues arising from corners and bends, and reflection and multipath

interference issues arising from RF waveguide effects of confined spaces. Solutions should also address the power, weight, and volume constraints inherent with small UGVs.

PHASE I: Design a Wireless RF Communication Link system for use on small UGVs in enclosed environments. This system will have the capability to transmit near real-time, digitized video and status data from the UGV to the operator and control data from the operator to the UGV inside enclosed environments with a high degree of confidence. It will also have data relay capabilities to allow the UGV information to be integrated into the battlefield Command, Control, and Communications (C3) networks.

PHASE II: Develop and test a prototype unit. This unit will be integrated into a small UGV and tested in government test facilities. The performance characteristics will be compared against currently used, commercial off-the-shelf RF communications links.

PHASE III: Design changes will be initiated to solve design problems, integrate producibility and manufacturability into the design, and develop a technical data package for this system. The Wireless RF Communication Link will be integrated into the U.S. Marine Corps GLADIATOR and U.S. Army's Man-Portable Robot System (MPRS) UGV programs.

COMMERCIAL POTENTIAL: The potential for commercializing this product is tremendous. This Wireless RF Communications Link could be utilized in any enclosed work environment requiring wireless local area networks (LAN) for data communications. Current technologies used for LANs are susceptible to interference, jamming, and increased electromagnetic noise levels. The technologies developed under this effort will be inherently less susceptible to these types of interference because mitigation of this type of interference is part of the design of the system.

KEYWORDS: Radio; unmanned; data; communications; tunnel; wireless.

N01-112 TITLE: Internal Periscope Displays for Embedded Training

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Advanced Amphibious Assault Vehicle (AAAV), ACAT ID

OBJECTIVE: Develop and demonstrate a Visual Display monitor that can be built into the periscopes on the AAAV. The display will remain permanently inside the periscopes. It must have two modes; one in which it is switched OFF i.e. positioned out of the way so that the vehicle operators can see through the periscope to the outside of the vehicle; and a second position where the display is switched ON, i.e. positioned in the periscope path to become an opaque display for presenting the simulated Out-the-Window (OTW) view provided by the on-board Embedded Training Simulator server.

DESCRIPTION: During the past decade the U.S. Army and U.S. Marine Corps, in parallel with many foreign militaries, have demonstrated their commitment to deployable "embedded training" using appended, or "strap-on", simulation and control systems to make operational armored vehicles serve a second purpose as a crew trainer. Armored communities place the highest priority on deployable embedded training to sustain highly erodable skills. Marine Corps units embarked on Naval Ships are in special need of high quality training devices sufficient for maintaining the crucial precision gunnery skills of target detection, identification, and engagement. Computer servers for embedded training have been miniaturized and ruggedized to a state that they can be fully integrated into the armored vehicle. However, visual displays must still be carried in separate packaging and strapped on manually whenever simulation training is desired. External displays are at risk of being left behind as embarkation space is given to higher priority war supplies such as ammunition, food, and water. Displays that have labor intensive installation and exposed cabling are at risk of severe damage during installation and use by Marines. Reliable, robust displays are crucial to the success of embedded training. The optimal solution would be displays that are permanently built into the vehicle with no exposed cabling. The most natural display location for training would be at the periscopes so that operators would look to the same location whether they are looking out to the real world or using the embedded training simulator system. Flat panel displays that could be made small enough to "strap-on" to the periscopes would partially fill the need but would still have the high likelihood of becoming damaged to the point of being unusable. Any display solution that requires storage, installation, and exposed cabling cannot be expected to survive in the rugged environment experienced by AAAV. Fully integrated displays are needed to provide superior training devices for the life of the vehicle.

PHASE I: Perform a feasibility study and develop a preliminary design to describe the following: (a) Mechanism for a display that can be switched or moved to provide an "ON" mode where it functions as a display, and an "OFF" mode where it is out of the visual path. (b) Potential to be mounted internally in periscopes with sufficient image quality to serve as a training device. (c) Method for receiving signals from a computer server to provide graphic imagery. (d) Electrical power requirements. (e) Provide an estimate of the cost, schedule, technical performance, risk, and producibility of the desired capability.

PHASE II: Develop a detailed design and produce prototypes to demonstrate the capabilities described in Phase I. Multiple prototypes of varying form can be used to demonstrate different aspects of the design. One prototype must demonstrate that the design can provide sufficient image quality to serve as a training device display. One prototype must demonstrate, inside a mock-up of the AAAV periscope, the mechanism to be used which allows the display to be visible on command and be move out of the visible path on command. Each prototype must demonstrate the capability respond to contractor provided computer imagery software. Update and refine the estimate of the cost, schedule, technical performance, risk, and producibility of the desired capability. Develop a commercial marketing plan for the system.

PHASE III: Integrate display design with the AAAV Embedded Training software. Fabricate ruggedized periscope displays of appropriate size to fit in the AAAV driver's periscopes and the AAAV Vehicle Commander's periscope. Produce sufficient periscope displays to outfit one AAA Vehicle. Integrate the periscope displays into AAAV periscope housings. Determine reliability characteristics of the internal periscope displays. Demonstrate producibility and develop an implementation plan for new production. Further develop the system for both commercial and military applications. The resultant system shall be made commercially available by the close of Phase III.

COMMERCIAL POTENTIAL: The commercial video gaming industry can benefit from the miniaturization of displays for creating high quality visual displays with small volume space claims. Commercial applications which use a display surface that would benefit from being transparent at times such as the commercial automotive industry which has featured instrument panel readouts shown on the windshield.

KEYWORDS: Displays, miniaturization, training, internal, simulation, embedded.

Naval Sea Systems Command (NAVSEA)

N01-113 TITLE: Shipboard SMART Foundation Adapter

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1: DD21

OBJECTIVE: Develop and demonstrate a standard, lightweight, low-cost adapter to accommodate shipboard COTS equipment and provide a flexible, reconfigurable interface to the shipboard standard foundation interface SMART Track mounting system and shipboard equipment.

DESCRIPTION: Shipboard electronics and other spaces require frequent upgrades and/or reconfigurations due to technology and other changes; such changes are only projected to multiply with increased use of COTS for military systems. Often these upgrades require extensive ship alterations associated with modifying ship support services. To decrease costs and increase adaptability, open interfaces for equipment foundations are becoming a reality with the use of SMART (Shipboard Modular Arrangement Reconfiguration Technology) Track on Navy ships. SMART Track is a modular commercial foundation system based on ISO Standard 7166 and is currently installed on several Navy ships. SMART track installations provide a significant cost avoidance by simplifying the structural work involved in reconfigurations or upgrades. However, current installations of equipment to SMART track require the use of individually constructed intermediate foundations to connect equipment to the SMART interface grid. This can result in additional costs and in the equipment and consoles being raised several inches creating potentially unacceptable ergonomic arrangements. A significant cost avoidance would result from the development, qualification, and implementation of a standard, flexible adapter family to serve as the interface between various equipment types and mounting orientations and the standard SMART Track foundation. Such an adapter would be subject to demands of the Navy unique environment and must meet rigorous shock and vibration requirements. This adapter will be designed to eliminate the requirement to design and conduct shock analysis for each individual equipment foundation and allow flexible console/rack orientation and reconfiguration. This adapter will provide a low profile, direct link to equipment and consoles located in shipboard spaces.

PHASE I: Develop a standard, flexible, reconfigurable, low-cost, light-weight adapter family design for a range of shipboard electronic console applications. Conduct a study of the lifecycle costs and feasibility for use with the projected range of current and future shipboard electronics equipment. Develop a prototype and evaluate feasibility in the Navy unique environment with respect to shock and vibration requirements by conducting computational shock analysis.

PHASE II: Analyze, fabricate, and test the designs developed in Phase I. Conduct physical testing to validate that the designs can meet the requirements of NAVSEA 0908-LP-000-3010, Rev. 1 (or most recent Revision) "Shock Design Criteria for Surface Ships." Evaluate and project the lifecycle costs associated with the adapter. Validate the applicable ranges of individual adapters within the adapter family (weight, center of gravity, etc.).

PHASE III: Demonstrate and document the adapter's projected lifecycle costs, producibility, and adaptability for multiple equipment configurations as part of the installation and testing within a ship electronics space. Validate the adapter's shock/vibration qualification. Develop a plan to incorporate the adapter on CG 47 and LPD 17 Class ships as shipboard electronics spaces undergo construction or conversion.

COMMERCIAL POTENTIAL: Commercial ships that utilize electronic equipment could benefit from the incorporation of such adapters coupled with the ISO 7166-based SMART Track concept to maintain currency with the ever-advancing electronic/computing technologies by providing a low cost, rapid upgrade potential.

REFERENCES:

1. NAVSEA 0908-LP-000-3010, Rev. 1 (or most recent Revision) "Shock Design Criteria for Surface Ships".
2. NAVSEA Technical Manual S6468-AA-INM-010, "Technical Manual for Shipboard Modular Arrangement Configuration Technology (SMART) System SMART Design Guidance".
3. NAVSEA Technical Note No. 070-PMS335-TN-0018, "C4I Modular Implementation Working Group C4I Modular Foundation Study".
4. ISO Standard 7166.

KEYWORDS: Adapter; SMART Track; electronic equipment; foundation; mounting; interface.

N01-114 TITLE: Automated Shipboard Food Service

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop and demonstrate automated shipboard food service processes and technologies that will significantly reduce shipboard food item preparation, serving, and scullery manning requirements through automated identification, retrieval, transportation, processing, and preparation of menu items while enhancing the food quality and availability.

DESCRIPTION: The loading, stowage, preparation, and serving of meals to US Navy shipboard personnel is presently a manpower-intensive operation as is the cleanup of cooking, serving, and eating utensils and disposal of foodservice waste (scullery functions). These shipboard processes are almost entirely manual with minimal modern equipment and little automation; others do not positively effect the morale of shipboard personnel. Requested is an integrated system(s) addressing food item preparation as well as clean-up to eliminate the workload currently associated with these operations. The Food Item Preparation System (FIPS) would automate the identification, retrieval, and transportation of food items from the shipboard dry, chill, and freeze storerooms to the preparation area(s) (galley). The FIPS would also initiate, monitor, and control food item preparation and serving processes within the galley. Inventory and menu management features would support automatic recordkeeping and ordering. The Scullery Management System (SMS) is the counterpart to FIPS and will perform scullery functions such as messgear scrapping, soaking, washing/drying, and stowage, with no attendant manpower requirements. The FIPS and SMS will be developed with a modular, open systems architecture approach to permit lifecycle upgradability, flexibility for inclusion of various commercial technologies/systems, and application across various ship platforms and Navy/Industry support concepts. The FIPS and SMS are envisioned to include computer-controlled sensors and operating mechanisms able to operate in refrigerated spaces and withstand shipboard motions/ environment. Previously, technology insertion aboard Navy ships has occurred at the piece-part level and current shipboard foodservice arrangements do not facilitate upgrade or modernization except in the most rudimentary manner. Existing Navy ships typically are configured with foodservice storerooms separated from the food production areas, contributing to manpower-intensive stores handling. The development of a re-engineered foodservice system and the implementation of innovative automation technologies to minimize the manpower requirements for shipboard foodservice are required. New methods and techniques for the stowage, retrieval, preparation, and management of menu items are required. These new methods must employ automation and mechanical aids designed for operation aboard Navy ships and must reduce overall ship system requirements such as chill/frozen storage.

PHASE I: Develop an automated FIPS and SMS concept for Navy surface combatants to eliminate Scullery manning requirements and reduce the number of food item preparation and serving personnel. Identify the resultant manning reduction, lifecycle costs and shipboard impacts and performance in the Navy unique environment. Develop prototypes and demonstrate key equipment and processes. Identify required equipment, menu and menu items, concept of operations, architectures, and interfaces including HSI, ship-machine and with existing and planned logistical support communities.

PHASE II: Prototype the automated foodservice concept as determined in Phase I. Demonstrate (land-based) the operation of processes and individual items including defining maintenance procedures and projecting lifecycle costs for all Navy shipboard operational scenarios. Define interface boundaries and conditions for new system processes and equipment to address legacy

Navy systems such as shore-side/underway logistics systems, inventory management/accounting tools, and ship general arrangements. Evaluate performance in the Navy unique environment including shock and vibration requirements.

PHASE III: Demonstrate the automated foodservice system configuration aboard a US Navy ship operated by Navy personnel. Document manpower reduction, lifecycle cost projections, maintenance requirements, impacts and interfaces with other ship systems and the existing and planned logistical support communities, and performance in the Navy unique environment. Develop a plan to incorporate automated foodservice system concept on new construction US Navy platforms.

COMMERCIAL POTENTIAL: Cruise ships, cargo ships, tankers, and workboats in the commercial sector could benefit from the incorporation of automated food service technologies and approaches, as could MSC and USCG ships. US Navy shore-side and other governmental, institutional, and commercial installations could benefit from automation and other technologies used to reduce manpower and streamline system operation; the ability to effectively employ an automated foodservice system within a confined [shipboard] area will appeal to the commercial sector as a cost-effective space optimization measure.

REFERENCES:

1. "NAVSUP Advanced Food Study aboard USS McFaul", Naval Supply Systems Command, Mechanicsburg, PA, September, 1999.
2. "Modular Reefer Box Technology Demonstrator", Naval Sea Systems Command, Affordability Through Commonality Program (PMS 512), Arlington, VA, December, 1997.
3. "Co-Located Galley Life Cycle Cost Analysis for the Affordability Through Commonality Program," August 1997,prepared by Naval Sea Systems Command, PMS 512 under Contract # N00024-92-C-4215: TI 6A016.
4. "Commercial Applications in Aircraft Carriers", Naval Sea Systems Command, PMS 312, Arlington, VA, March, 1999, prepared by MSCL Incorporated under Contract # N00024-95-C-4180: TIs 7J201, 8J008, 8J020, and 8J108.

KEYWORDS: Automation; food processing; food preparation; food stowage; food procurement; sustainment.

N01-115 TITLE: Human System Integration Rapid Analysis Tool for Evaluation of System Concepts Early in Development

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop and demonstrate a computer-based human systems integration (HSI) tool that supports the rapid assessment of human performance, health and safety issues, and average expected workload for a ship manpower optimization concept (or concepts). To accomplish this, the tool should use characteristics of the tasks, task timelines, situation awareness, and tactical perspective. The tool should produce manpower summaries for competing automation concepts by NEC and rating, or other suitable descriptors of the necessary operator/maintainer knowledge, skills, abilities (KSAs) and experience. The tool should help assess the extent a design concept enhances or impedes the situation awareness and tactical perspective. These outputs should be directly applicable in trade studies assessing the expected manpower cost and human performance aspects of competing system concepts. The tool should also provide the basis for quick assessments of the aspects of a design concept that will impact human performance, safety, or health in an optimized manning environment.

DESCRIPTION: Manpower reductions or manpower optimizations are features of many current Navy acquisition projects. In some instances, it may be possible to specifically state which watchstanders or maintainers dedicated to a given shipboard system can be eliminated, provided the corresponding hardware operations or maintenance activities can be fully automated, deferred, or otherwise eliminated. More typically, however, watchstanders or maintainers work across a variety of related systems. In such cases, system concepts for complete automation, partial automation with supervisory control, remote operation, reliance on decision support systems, etc. produce distributed workloads that must be allocated to individuals having the necessary KSAs, and then rolled up across systems for a given category of watchstander/maintainer. To perform the necessary analyses, process-modeling tools have been applied to the CVNX program, and task network simulation tools have been proposed for application to DD 21. In both cases, the proposed tools require fairly extensive knowledge of the sequential or network properties of the operator and maintainer tasks. This knowledge is seldomly available in the concept definition and exploration phase. At their best, these tools require labor intensive and time-consuming data collection efforts.

The tool to be developed should be specifically tailored for use in the concept exploration phase of the system acquisition cycle. It will permit rapid approximations of workload and manning requirements, and the potential for maintaining situation awareness and tactical perspective of competing system design or automation concepts. The rapid workload analysis element of the tool should utilize a small number of task and activity parameters, such as mean duration, task frequency, manloading, and other conditioning factors. The intent should be that the parameter sets will be amenable to rapid definition using subject matter expert (SME) inputs regarding predecessor systems, and modification of these parameter sets for alternative concepts using

human role definitions rather than explicit manned stations or NECs. The tool should include a database of typical shipboard watchstander and maintainer tasks with representative parameters and parameter estimation guidance. A simplifying factor that reduces the number of free parameters to be estimated for a given concept is that for many shipboard tasks, the task frequencies will be defined or constrained by the use of mission scenarios. These scenarios will contain events, such as multi-track engagements or equipment failures, which call for certain functions in the model to be performed. Therefore, the frequencies of certain tasks will be amenable to estimation from the scenarios.

Mission scenarios should also be used to determine the potential for successful task performance under conditions of tight time constraints and high information loads. The human performance element of the assessment tool should focus on the extent to which a design concept facilitates or impedes human performance for a selected scenario. The tool should contain a data base of typical shipboard tasks with indications of HSI problems identified in existing ships and existing implementations of ship systems, with emphasis on the cognitive aspects of these tasks, such as short term memory, information integration, decision making, situational awareness, and maintenance of tactical perspective. The range of HSI problems catalogued should include human performance problems (human error incidence, excessive time to perform, excessive cognitive workload, etc.), safety problems (hazards and accident rates), and health problems (incidence of ergonomic injuries, heat or cold stress, noise effects, etc.).

PHASE I: Define the software and user-computer interface (UCI) requirements and identify the host application under which the tool will run. The host should be generally available to prospective users. Define example scenarios, conditions, functions, tasks for a representative ship and its representative systems. Develop a model of user-tool interactions and transactions in representative tool use situations.

PHASE II: Develop version 1 of the software and beta test this prototype using input from representative end users. Modify the software accordingly. Define a set of representative systems, missions, scenarios and functions and populate the function/task database. Develop guidance for estimation of function/task parameters by applying the software and data to a representative competing concept evaluation. Produce user guide documents.

PHASE III: Produce and market the software and make it available to suitable Navy agencies and contractors, and promote the use of the workload/manpower analysis tool in concept evaluation efforts within selected acquisition programs such as DD 21.

COMMERCIAL POTENTIAL: The workload analysis tool will be applicable to any business process re-engineering initiatives involving manpower optimization or the analysis of manpower requirements based on operator/maintainer workloads

KEYWORDS: Manpower; Workload; Human Systems Integration; Human Reliability; Health and Safety Computer Tool.

N01-116 TITLE: Embedded Training in an Optimized Manning Environment

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop and demonstrate a methodology for conducting embedded training in optimized manning environments aboard naval ships.

DESCRIPTION: Future Navy ships will be operated and maintained by significantly fewer sailors. Increasing use of automation, along with improvements in system reliability are behind this trend. The next generation of surface ships will increase their use of reliable automation resulting in the reduction of the number of personnel required to maintain and operate warfare/warfare-support systems. This reduction in manning results in fewer people requiring training, fewer trainers, and the training required involves learning details of complicated systems. It becomes apparent that embedded/tightly-integrated training will be required. However, embedded training, to be effective, must correspond and respond to the new manning environment. The effects of this new environment on training, particularly embedded training methods and systems, are not well understood. Team and proficiency maintenance training in this reduced manning environment will require new methodologies, since both the number of operators being trained and the training personnel available to conduct training will be reduced. Current embedded training capabilities, such as the Advanced Embedded Training (AET) system and the ongoing Synthetic Cognition for Operational Team Training (SCOTT), need to be extended to ensure individual competencies and supporting team behaviors can be assessed, deficiencies diagnosed, and training executed within the lifelines. The research and methodologies generated by this SBIR will lay the foundation for new training paradigms that will be effective in this type of environment.

PHASE I: Research individual and team training requirements for a reduced-manning Combat Information Center (CIC). Design, develop, and document a methodology for conducting scenario-based training, dynamically assessing team performance,

providing real-time feedback, and automatically generating tailored training for identified deficiencies. With manning reductions of 70% targeted for DD 21, a commensurate reduction in training personnel must also be targeted.
The AET program demonstrated a 50% reduction in trainer resources for training execution. This was combined with methodologies that improved teamwork performance by over 30%. However, these advances must be improved and address not only training execution but planning, debrief, and post-exercise remediation. This methodology must include the ability to rapidly generate training scenarios, archive individual and team performance profiles, associate observed behaviors to approved training metrics, and automatically generate individual and team training recommendations. In addition, the training methodology must accommodate both trainer-augmented and trainer-less scenario-based training sessions.

PHASE II: Develop a prototype of the system described in Phase I. Develop a detailed design document for the embedded training prototype. Corresponding guidelines or instruction manuals should also be developed and documented.

PHASE III: Produce and market the final system design. Develop design(s) for implementation into other shipboard teams and other ship classes (CVN, LPD-17, etc.).

COMMERCIAL POTENTIAL: This methodology will have applications to military, government and private sector organizations in which high performance skill retention and/or a high degree of cross training is applicable.

REFERENCES:

1. Chief of Naval Operations (N86) Operational Requirements Document for Land Attack Destroyer (DD-21) dated 3 December 1996.
2. Cannon-Bowers, J. A. & Salas, E. (1998) Individual and team decision making under stress; Theoretical underpinning. In J. A.
3. Cannon-Bowers & E. Salas (Eds.), Making Decisions Under Stress: Implications for Individual and Team Training. (pp. 17-38). Washington, DC: APA Press.
4. Dwyer, D. J., Oser, R. L., Salas, E., & Fowlkes, J. E. (1999). Performance measurement in distributed environments: Initial results and implications for training. Military Psychology, 11(2), 189-215.
5. Stretton, M. L., Johnston, J. H. & Cannon-Bowers, J. A. (1999). Conceptual Architecture for embedded team training management. Human/Technology Interaction in Complex Systems, 9, 87-120.
6. Oser, R. L., Cannon-Bowers, J. A. Salas, E., & Dwyer, D. (1999). Enhancing human performance in technology rich environments: Guidelines for Scenario-Based Training. In E. Salas (Ed.), Human/Technology Interaction in Complex Systems, (pp. 175-202).
7. "Decision Making in the AEGIS Combat Information Center," Hall, J. K., et. Al., I/ITSEC Proceedings, 1998.

KEYWORDS: Onboard Training; Embedded Training; Training Systems; Training Methodologies; Team Training; Scenario Based Training

N01-117 TITLE: Non-Lethal Ship Defense Response Systems (Anti-surface)

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop and demonstrate non-lethal anti-surface ship defense weaponry that is compatible with and can be successfully employed in a shipboard environment with minimal impact to current ships. At a minimum, weaponry should provide sufficient deterrent "barrier" capability to permit a ship's crew to readily distinguish a determined adversary from a straying civilian.

DESCRIPTION: Surface ships, including surfaced submarines, are most vulnerable to unconventional attack when they are anchored, pier side, or forced to transit narrow chokepoints such as the Strait of Hormuz or the Suez Canal. Current technology forces commanding officers to rely on manpower intensive use of picket boats and sentries who have only pyrotechnics, fire hose, or small caliber live warning shots to fend off approaching persons or surface craft of unknown intentions. These methods are not only slow and burdensome in employment but they may also harm the straying innocent civilian. They are also unlikely to adequately slow or otherwise permit identification of a determined adversary at ranges sufficient to permit employment of lethal force. Ship commanding officers require a non-lethal defensive mechanism that are employable from current ships, in port and underway, and involve minimal manpower. Application would be against approaching persons or surface vehicles, both land and waterborne. The mechanism need not completely disable a suspect person or vehicle; it must only provide sufficient discomfort and deterrence such that only a dedicated enemy would persist in advancing or continuing actions. Its use must not result in permanent injury. It would be highly desirable if the compactness of the technology would permit employment from small watercraft and SH-60 class helicopters. Candidate technologies might include a combination of high velocity water cannon, eye-safe laser dazzlers, high intensity acoustics, pulsed power and directed energy devices. All such mechanisms must

be able to withstand the rigors of the shipboard environment, be near instantaneous in reaction time, and variable in intensity such as to provide initial effects at 300 meters and effective deterrence at a range of 150 meters without adversely effecting own ship crew, ship systems or the environment.

PHASE I: Develop and vet SBIR test scenarios, objectives, and requirements. Develop and demonstrate selected technology(s) to 100-meter range in static test environment.

PHASE II: Integrate selected technologies if required. Demonstrate effectiveness of selected technologies in simulated shipboard environment to 150-meter range under all test conditions. Demonstrate safety features. Collect, analyze, and present test data.

PHASE III: Install prototype system on test vessel of Navy choice for 6-month evaluation period. Collect, analyze, and present reliability, maintainability, and availability data.

COMMERCIAL POTENTIAL: This technology has wide application in both government and commercial security business (high value site protection) and in law enforcement (non-lethal weapons/crowd control).

REFERENCES:

1. USS Cole investigative report (in progress).
2. DD21 Design Reference Mission (DRM) environmental conditions.

KEYWORDS: Non-lethal weapons; ship defense; counter terrorism weapons; unconventional weapons; barrier defense; trip wire.

N01-118 TITLE: Surveillance of Ship Security Perimeter While in Port

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop and demonstrate a surveillance system to monitor personnel and small craft activities around the security perimeter of naval vessels while in port. The system must be able to detect and track the movements of non-authorized personnel/craft within the security perimeter. The system should incorporate a knowledge-base of procedural and intelligence issues tied to surveillance data to discern movement patterns that will be used to recognize non-authorized personnel/craft. In addition, the system should work in conjunction with auxiliary sensors to identify authorized versus non-authorized personnel. The perimeter monitoring security system will perform security surveillance, detection and tracking activities. Its control interface will be simple to operate and located in in-port manned watch stations areas convenient to shipboard security personnel. Once identification has been made, surveillance system interface with non-lethal devices should allow deployment of the device at crew's discretion in response to various threat conditions.

DESCRIPTION: A perimeter monitoring security system can be developed to provide dockside and adjacent water coverage for detection and tracking of unauthorized personnel or vessels within a ship's security perimeter. Simulations should be developed to evaluate the performance of the candidate surveillance systems for their ability to provide appropriate detection coverage capabilities such as clutter mitigation and probability of detection for land-based and water-based targets. The program will require the development of software that will be able to identify non-authorized personnel along a dockside and water perimeter, and track their movements inside a security perimeter. A n easy-to-use perimeter monitoring security system will be developed which will display, on a dedicated security monitor, the current location and track history of all non-authorized personnel within the ship's security perimeter. The system will also provide visual and auditory alarms of all security perimeter breaches. The perimeter monitoring security system should coordinate with other shipboard security sensors such as Low-Light TV/Forward-Looking Infra-Red (FLIR), CCTV, and motion sensors for additional coverage and identification capabilities. The prototype perimeter monitoring security system should be a stand-alone, PC-based system. It should not interfere with other ship radar activities or other security operations.

PHASE I: Develop a system concept including sufficient detail to convey physical and performance characteristics. Evaluate existing surface-search/navigation radar systems for their suitability in the detection and tracking of human*f*{sized targets in a port area. Analyze the dynamic clutter environment of coverage areas in sample ports, determine the probability of detection in those areas, and develop initial clutter models for this environment. Phase I also will include tie-ins to existing C3I systems and evaluation of existing supplemental sensor systems such as Low-light TV/Forward-looking Infra-Red (TV/FLIR) sensors.

PHASE II: Develop a prototype of the perimeter monitoring security system. The monitoring system shall be able to detect, track and identify non*f*{authorized personnel who breach the land and water perimeter. The perimeter monitoring security

system shall have a user-friendly interface and require minimal training to operate. During this phase, the prototype system will be evaluated in sea port trials.

PHASE III: Develop perimeter monitoring security system specifications and begin production of security systems for widespread distribution to the fleet.

COMMERCIAL POTENTIAL: Technology developed for ship perimeter monitoring will transition easily to perimeter monitoring of other assets, including large land areas of military bases and commercial properties.

KEYWORDS: Surveillance Radar, tracking algorithms, radar cross section, clutter, probability of detection, perimeter security

N01-119 TITLE: Simulation Environment in Support of Non-Cooperative Target Recognition (NCTR) Algorithm Development

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: To develop and demonstrate a software/hardware simulation environment concept in support of Radar/IR NCTR algorithm development effort. The simulation environment must be capable of providing realistic and repeatable sensor measurements against specific targets in specific geometries and external environments in realistic processing times, with interfaces that are manageable by typical users.

DESCRIPTION: The NCTR problem is one of the most complex issues facing the Navy within the context of air and space defense. Within the area of air defense, shipboard sensors may be tasked in discriminating among many complex targets, which may contain any mixture of friendly, neutral, and hostile populations. To increase the probability of correct identification, and minimize the probability of incorrect identification, multiple sensors may have to be employed, and from more than a single platform. This topic is concerned with the specific combination of radar and infrared search and track (IRST) sensors, operating from a single platform. Since the discriminates in questions may be complex and varied, developing the required algorithms will necessitate the availability of high fidelity sensor, target, and environment modeling tool, representing both radar and IRST, which will account for the different sensors and their operating modes, changing environments – including clutter, propagation, sea, and terrain – target particulars, and relative geometries. The function to be served by such a simulation cannot be fully served by field measurement since field measurements (a) are expensive to obtain, (b) cannot be taken with notional sensors, (c) cannot cover all geometries, environments, and threats in question, (d) do not always provide precise knowledge of the geometries prevailing at the time of the measurement, and (e) are not repeatable. Whereas the role of the simulation environment is to resolve fundamental issues, help support the algorithm development, and provide vigorous exercising to the techniques, the role of field measurements is to provide the final validation to already developed algorithms.

PHASE I: Develop a simulation concept in support of NCTR technique development based on the combination of radar and IRST sensors. Define the required architecture, including provisions for growth; identify the necessary software/hardware components; and classify such components by availability vs. need to develop or extend.

PHASE II: Construct a simulation prototype and validate its outputs via comparison with limited live test data. Demonstrate the utility and growth potential of the simulation prototype via relevant examples of its use.

PHASE III: Insert the capability in a non-SBIR Navy program in support of air threat radar/IRST NCTR algorithm development activity. Support the evolution of the tool through on-going synergy with the NCTR algorithm development program. Study the potential contribution of additional sensors – co-located or from distributed platforms - to the NCTR performance, and expand the simulative tool accordingly.

COMMERCIAL POTENTIAL: The resulting tool should have multiple users within all of the military communities concerned with NCTR issues – i.e., Navy, Air Force, and Army.

REFERENCES:

1. Xpatch/Npatch/FISK SAIC/DEMACO References
2. Clutter Modeling References
3. Radar Modeling and Simulation References
4. IRST Modeling and Simulation References
5. Propagation Modeling References

KEYWORDS: Simulation; Target Signature; Sensor; Environment; Propagation; NCTR; Radar; IRST

N01-120 TITLE: Global Positioning System (GPS) Jamming Situational Awareness for Naval Surface Fire Support (NSFS)

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II - Extended Range Guided Munition [ERGM]

OBJECTIVE: Develop technologies that will provide users of Naval Surface Fire Support (NSFS) weapons such as the EX 171 ERGM situational awareness of the GPS jamming environment. These technologies will provide the ability to measure jamming or interference of the Global Positioning System (GPS) signals, assess how the jamming will affect the weapons, and take actions to reduce the impact of jamming.

DESCRIPTION: New weapons for Naval Surface Fire Support, such as the EX 171 ERGM, use GPS as their primary means of navigation. The projectiles also carry inertial instruments that are aligned and calibrated by GPS early in the mission, to provide back-up navigation if GPS is later jammed. The inertial instruments also provide inertial aiding of the GPS, increasing its anti-jam performance. The projectile also has multiple GPS antennas, which permit it to null the signals from a small number of jammers. But these weapons have a limited number of antennas and a low goal for production cost, and so are not invulnerable to GPS jamming. This topic seeks technologies that will help ships firing NSFS missions to measure the GPS jamming and interference environment, predict how this environment will affect weapon performance, and take action to best employ the weapons in the face of jamming.

The system should be able to combine organic and off-board sensors to measure jamming levels, characterize the jamming signals (for example, narrowband vs. wideband, and directional vs. omnidirectional) and geographically locate the signals with enough accuracy to predict their effect on the weapons' receivers. Organic sensors can be deployed in gun projectiles (free-flying or as a parachute payload), with weather balloons, or using the Forward Air Support Munition. (FASM is an expendable gun-launched aircraft under development, capable of carrying a payload 4.5 inch in diameter and 20 inches long and flying for three hours, although a smaller payload would be desirable, to allow it to be carried along with other mission payloads.) The cost of expendables must be kept low, to be compatible with the weapons costs themselves. (NSFS must be affordable, and resources applied to understanding the GPS environment must be balanced against improved anti-jam capability in the weapon, or the use of more expensive weapons like Tomahawk.) The ability to incorporate off-board sensors such as signals intelligence aircraft is valuable, but the system must be able to operate using organic assets only, and not depend on scarce manned aircraft or large UAVs.

The predictive capability should include the following features:
1. Predict, for a given weapon and class of target, the effectiveness of the weapon (based on both the probability that the weapon may not acquire GPS initially, and the loss of accuracy resulting from loss of GPS later in flight.)
2. Compare the differing impact of jamming on different versions of the weapon and different weapons. (Later versions of a weapon may include better anti-jam equipment or different navigation instruments).
3. Account for the impact of different trajectories that may be available to the weapon.
4. Assess the ability to carry out multiple-round-simultaneous-impact firings (a tactic where multiple rounds are fired at the same target, with earlier round fired on trajectories that have longer flight times, so all rounds arrive at about the same time.)
5. Examine alternative of ship stationing and offset firing to improve anti-jam performance. This capability will allow ship commanders to improve their weapon performance by repositioning their ship.

PHASE I: Develop a system approach for GPS jamming situational awareness, and establish critical technologies needed to implement this system. Conduct critical field experiments or bench-scale tests if needed to establish the feasibility of the approach. Assess the performance of the approach in a simulation.

PHASE II: Develop the key technologies identified in Phase I. Fabricate, test, and evaluate them in a stand-alone prototype of the system designed in Phase I

PHASE III: Integrate the prototype system into the shipboard combat system as a tactical decision aid. Near-term integration will be into the Naval Fires Control System, which itself is being integrated into the Aegis Combat System.

COMMERCIAL POTENTIAL: As GPS becomes a greater part of civil aviation, commercial surveying, and time synchronization of wireless data networks, the necessity for users and government agencies to quickly locate sources of interference to GPS is growing. This system will provide such a capability to the FAA, the FCC, and the end users. More generally, the technologies developed will also be applicable to location of other sources of radio interference.

KEYWORDS: Global Positioning System, jamming, interference, situation, awareness, environment

N01-121 TITLE: Non-GPS Projectile Navigation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II - Extended Range Guided Munition [ERGM]

OBJECTIVE: Proved an alternative navigation approach for guided projectiles, to provide for situations where the GPS signal is unusable because of enemy jamming.

DESCRIPTION: GPS jamming is a significant threat, and countering jamming is the focus of substantial research, development, test, and evaluation effort. GPS-guided weapons, including projectiles, incorporate anti-jam features that go far to mitigate this threat. However, a determined enemy can still jam GPS. This is a particular concern for developers of gun projectiles, because the projectile is designed as a "wooden round" with a 20-year shelf life. Projectiles are bought in a large lot and stored with no maintenance and no opportunities to backfit improved antijam features. Gun projectiles are expected to be low cost, and it is not feasible or cost-effective to pull projectiles from inventory, disassemble them (with due regard for their explosive warhead and energetic rocket motor), and install upgrades. For this reason, the NSFS program desires that projectiles contain an approach to navigation that is independent of GPS, and can function despite the best effort of an enemy 20 years in the future to jam GPS.

PHASE I: Develop an approach to navigating in a jamming environment that makes GPS totally unavailable. (GPS anti-jam approaches are not desired in this topic. Neither are GPS signal augmentation and "pseudolites" approaches, since theses are already being developed in other efforts and additional work in this area is not desired). The most important requirement for the approach chosen is that it fit inside the projectile, in all ways. That is, it must physically fit, it must function in the projectiles environment including surviving gun launch, and it must fit the projectile's cost budget, adding no more than about $5000 to the cost in production quantities of 10,000 units. After this constraint, it is desired to minimize the external support required to permit non-GPS navigation. So, an approach that reduces the need to deploy or survey-in base stations is desirable, as is an approach that uses cooperative or non-cooperative signals of opportunity. (The jammers themselves can be used as signals of opportunity, but with due consideration for the difficulty in "surveying in" these emitters.) Finally, within these constraints, accuracy comparable to GPS is desired, with degradation to 50 meters CEP allowable if necessary. In Phase I, the contractor should demonstrate the feasibility of the proposed concept through analysis, simulation, and conduct of critical experiments. Critical experiments should show that the observable that the navigation system measures can in fact be detected and measured by the projectile with sufficient accuracy to support navigation.

PHASE II: Develop a prototype of a navigator that uses the approach demonstrated in Phase I. Characterize its performance, and determine the operational conditions under which it will and will not function properly. The prototype need not be miniaturized to fit in a projectile but there must be a clear path to a projectile-sized navigator. The design and prototype may assume the projectile has a GPS receiver including frequency reference and antennas, low-grade inertial navigator, flight control computer, power, and digital interface for initialization; development effort should focus on components beyond this baseline. To ensure low cost and small volume, approaches that reuse much of the GPS receiver, and approaches that are based on a large-volume commercial production base, are encouraged.

PHASE III: The navigation capability developed by the contractor would be used in the EX 171 Extended Range Guided Munition and in the projectile for the Advanced Gun System, with additional applicability to the Army XM 982 "Excalibur" and Navy Advanced Land Attack Missile.

COMMERCIAL POTENTIAL: The navigation technique developed in this topic will have applicability to the following areas:
1. Very low cost navigation in devices that already receive a non-GPS signal, such as portable telephones, wireless data devices, and instrumentation systems
2. Backup or cross-check to GPS for safety-critical installations.
3. Navigation in areas not well-covered by GPS—indoors, in urban "canyons", or in open-pit mines.
4. Ground-truth for testing of GPS systems, especially conducting tests that assess susceptibility of commercial GPS systems to interference.

KEYWORDS: Navigation, GPS, ranging, jamming, accuracy,

N01-122 TITLE: Modeling High-Temperature Erosive Gas Flow to Support Barrel Erosion Reduction Concept Modeling for Fire Support Gun Application

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II - Gun Weapon Systems Technology program

OBJECTIVE: Develop the modeling and analysis tools needed to implement erosion-prevention technologies. These tools will be used to explore new concepts of barrel materials, coatings, linings, rifling, and interior geometry and their interaction with high-energy, high-temperature propellants and high firing rates. They will be applied to upgrades to existing guns such as the Mk 45 5-inch gun, and to the new 155-mm Advanced Gun System for DD 21. The tools will allow these programs to select and justify the correct combination of technologies to extend the erosion-limited life of the barrel, while having a minimum impact on operational utility (such as the ability to fire both spin-stabilized and despun projectiles), ease of fabrication, and barrel fatigue life.

DESCRIPTION: Next generation high energy guns, for reasons of efficiency, range, and cost will fire projectiles with fast burning, densely packed, high temperature propellants. These propellants will allow guns to produce 80 to 100% more muzzle energy than using today's propellant technology. Unfortunately these performance improvements come at the cost of higher propellant gas temperatures. Current known propellant chemistries all produce higher internal energy along with p-V, work energy. Traditional methods of formulating a propellant with a cooling agent of some sort are limited because of the need to maintain high overall energy density. Additionally, high loading density geometries, which increase muzzle energy even more effectively than high-energy chemistry, place even greater heat loads on the barrel.

Currently, barrel designs that incorporate refractory or ceramic-like materials are being considered to remedy this situation. All these concepts can be expected to require a considerable investment in new material and manufacturing technologies. What is being sought in this topic is the development of a high-fidelity computer modeling tool that draws on state-of-the-art coupling of computational fluid dynamics and finite element modeling, incorporating results from the data analysis of ongoing government development efforts, plus any key experiments the contractor requires. This modeling tool will then be used to compare and assess the gains in erosion life resulting from various combinations of innovative erosion-reduction technologies applied to the Mk 45 Mod 4 and the Advanced Gun System (AGS). It is expected that through a host of unexplored design solutions such as geometry changes in barrel hot sections, rifling profile modifications with accompanying obturator designs, hot section surface coatings, and boundary layer additives that the near-term need of improving the Mk 45 Mod 4 erosion life by 100% can be met.

PHASE I: Create a physics-based parametric model of the gun barrel erosion process and calibrate it against a GFI data set based upon actual test firing and rocket nozzle erosion experiments. (The Naval Surface Fire Support program is currently conducting firing tests to assess the erosion problem and develop near-term solutions. Phase I and Phase II of this SBIR will have access to this data.) The model should account for effects such as barrel material and coatings, propellant properties of impetus and flame temperature, and gas flow and boundary layer effects. The model should be focused on representing the operating regime of 5-inch and 155 mm Naval guns, with sufficient scope for growth so that the model is a forward-looking tool that will support innovations and improvements to these guns. Validate the model against additional GFI data and against a higher-fidelity (but less easily used) modeling approach such as a first-principles computational fluid dynamic (CFD) analysis of current Mk 45 Mod 4 rifled and smooth bore gun tube. This validation will both show the correctness of the implementation of the parametric model, and will provide a first look at its utility as a tool for understanding the causes of erosion and for developing engineering fixes to problems.

PHASE II: Create a first-principles computational fluid dynamics code that predicts barrel erosion predictions in Mk 45 and AGS gun systems. Because boundary layer and turbulent flow effects are believed to be critical contributors to erosion, this code must accurately model these effects in two dimensions. However, the erosion predictions need only be 1-D results, estimating the severity of erosion at stations along the length of the barrel. The physical and thermal model of the barrel must be able to support steel barrels with linings or coatings that have thermo-chemistry very different from steel. This model shall be calibrated against the Phase I experimental data and against other physically based models in ab initio calculations. The model should be suitable for erosion-limiting design concepts in the existing Mk 45 Mod 4 gun system. So, it should be able to simulate firing of 40, 100, and 150 pound projectiles (representing the Barrage Round demonstration projectile, the Extended Range Guided Munition (ERGM) and the "Best Buy" demonstration projectile). These simulations should be at 18 to 25 MJ of muzzle energy, with proposed Navy propellant thermo-chemistries having maximum propellant flame temperatures of 3600 K.

PHASE III: The code developed in this SBIR shall be transitioned to interested contractors to aid them in evaluation and design of erosion reduction schemes, to government laboratories for the evaluation in barrel lifetime and wear investigations, and to the procurement process to improve the process of setting meaningful specifications, identifying MANTECH issues, and aiding the design evaluation process in this area.

COMMERCIAL POTENTIAL: Advanced thermo-chemical modeling in high temperature, high pressure, high carbon/ hydrogen atmosphere is directly applicable to thermal erosion problems in most internal combustion engines utilizing hydrocarbon fuels. The higher operating temperatures and pressures of guns represent the range of operation that higher efficiency engines are already moving toward. Special coatings and shapes such as are being modeled here will be directly applicable to next generation, hotter, high efficiency engines.

KEYWORDS: Computational Fluid Dynamics, Thermal Erosion, Thermo- Structural, Thermo-chemical, Gun, Rifling

N01-123 TITLE: Wireless Audio/Video Headsets

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: PEO Aircraft Carriers

OBJECTIVE: Develop and demonstrate wireless, full-motion, two way un-tethered, lightweight, portable audio/video headset compatible with existing aircraft carrier wireless interior communication systems (includes flight deck). Build a prototype and production model to demonstrate/field this capability.

DESCRIPTION: A need exists to provide wireless full motion, two way un-tethered audio/video in US Navy utilizing the existing interior wireless communications (includes flight deck) Radiating Transmission Line (RTL) as a wireless LAN with an interface to the ship's video Tele-conference (VTC) and exterior communications equipment. This capability would provide distant mobile Tele-Medicine, Tele-Maintenance, and damage control search & rescue in smoke and darkness. Develop recommended policy, procedures, specifications, and other required guidance to provide a selection process for addition of system on the wireless LAN. This is required to ensure configuration management, spectrum support, power level requirements, interoperability with existing systems, notional design, audio levels, video resolution, radio frequency environment, and Electro-Magnetic Interference (EMI), within the RTL and within the ship. Determine hardware requirements including interface hardware, recording equipment and all logistics support (parts, manning, and training) to implement on board aircraft carriers. Areas of risk include radio frequency environment, and Electro-Magnetic Interference (EMI) within the RTL and within the ship, capacity of Hydra RTL antenna to support multiple wireless devices, lack of spectrum support, Infra-Red spectrum, human factors interface (equipment weight, battery life, ease of operation).

PHASE I: Feasibility demonstration. Develop recommended policy, procedures, specifications, and other required guidance to provide a selection process for addition of this and similar systems on the wireless LAN. Design and conduct a feasibility study in a US Navy aircraft carrier. Determine spectrum support, power level requirements, interoperability with existing systems including the ship's VTC and Damage Control Self Contained Breathing Apparatus (SCBA), notional design, audio levels, video resolution, model the radio frequency environment, Infra-Red detection, and Electro-Magnetic Interference (EMI), within the RTL and within the ship (includes flight deck). Determine recording equipment requirements. Develop test procedures to determine that the engineering design meets or exceeds the requirements for operation throughout an aircraft carrier with a Hydra Block II RTL antenna system when the prototype is tested in phase II. The Phase I final report should include an analysis of alternative concepts as well as an assessment of cost.

PHASE II: Application demonstration. Design and develop a compatible wireless full motion, two way un-tethered audio/video into a suitable headset prototype device. The prototype should be lightweight, less than 15 oz. and user friendly. Design and develop the interface hardware to the ship's RTL antenna and the VTC equipment. Demonstrate the prototype headset, interface and recording equipment on an aircraft carriers RTL antenna system. Document all lessons learned for analysis and improvements during phase III. Provide a detailed engineering report of this testing. The Phase II final report should include an execution plan for Phase III, including cost and schedule.

PHASE III: TRANSITION TO PRODUCT DEMONSTRATION. Design and develop the production model headset, interface hardware and recording equipment. Develop full logistics support requirements (parts, manning, training) to implement on board aircraft carriers in accordance with NAVSEAINST 9083.1 (series) and other Navy guidance. Develop an implementation plan including estimated cost to procure/install on board aircraft carriers. Develop other appropriate Navy documentation to support a Navy program of record as required.

COMMERCIAL POTENTIAL: The commercial derivative of this device would have widespread application in public safety.

REFERENCES:
1. AN/SRC-55 HYDRA COMMUNICATIONS SYSTEM
2. NAVSEA DRAWING 53711-409-7338847
3. AN/SRC-55 Operational Requirements Document 430-06-96 dtd Mar 1966
4. Technical Manuals – COMMNET ERICSSON EDACS COMMUNICATIONS SYSTEM

KEYWORDS: Interior Communications; Wireless Video; Damage Control, Tele-Medicine, Tele-Maintenance

N01-124 TITLE: Advanced Power Distribution Systems

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID

OBJECTIVE: Develop and demonstrate an improved power distribution system that is more survivable, reduces equipment volume and weight, while reducing electric equipment outages during electrical system anomalies. The distribution hardware in presently configured systems utilizing solid state power supplies in the less that 50 kVA range does not provide the necessary electrical protection during short circuits. A new solid state distribution system should increase the electrical system survivability during system anomalies by providing improved fault detection time, improved fault isolation time, and a reduction in the interruption of power to unaffected electrical loads.

The function of the advanced power distribution system is to: (1) receive power from a power source; (2) distribute power to various power consuming loads via a solid state power controller; and (3) protect power consumers from system anomalies. The system will have to: (1) perform these functions over an acceptable long period under typical operating and environmental conditions; (2) have an operator interface; (3) interface with electrical power sources, loads, and digital communication systems; and (4) have various mechanical interfaces.

DESCRIPTION: The science and technology investment strategies have identified a need for technology development in the area of power and automation. The specific focus includes advanced electrical systems in the area of power distribution concepts, which are highly survivable and provide uninterruptable electrical power. Present electrical systems are being modified through the increased use of uninterruptable power supplied in small, distributed, radial designs. To ensure survivable and uninterruptable power during anomalies such as short circuits, the electrical protection system must ensure continuity of the electric power supply by isolating damaged sections of the system. Uninterruptable power supplying small (such as 5 kVA, 10 kVA, 15 kVA) systems are in a radial configuration.

The primary low voltage (nominal 120 vac), overcurrent and short circuit protection device utilized is the Navy ALB-1 circuit breaker manufactured in accordance with MIL-C-17588. Utilization of 5 kVA, 10 kVA, 15 kVA uninterruptable power supplies does not provide enough short circuit current to trip the larger size ALB-1 circuit breakers during short circuit conditions. Failure to "trip" circuit breakers supplying loads during these short circuit conditions will cause power supplies to shut down under overcurrent conditions and will secure power to all the loads being supplied by the power supply. The development of a low power electronic power controller will substantially improve overcurrent and short circuit protection of low voltage and low power systems by replacing electro-mechanical devices with non moving, silent operation electronic devices. The notional distribution system would be a new power panel consisting of: an enclosure; thermal management system; backplane used to receive and distribute power; plug in electronic power controller consisting of multiple single pole electronic switches mounted on circuit card assemblies; and control/power management/intelligence to allow manual and automatic settings. A secondary advance will be the development of an integral circuit breaker/motor starter. This device will provide overcurrent, short circuit, motor starting capabilities and will replace two pieces of equipment with one, thus reducing equipment and cable installation.

The system must operate within typical natural and induced environments such as high shock (MIL-S-901), vibration (MIL-STD-167-1), electromagnetic interference (MIL-STD-461), ambient temperatures ranging from 0 to 50 degree C, humidity ranging from 0 to 100% including conditions wherein condensation takes place in or on the equipment, and inclined up to 45 degrees from the vertical in any direction. The operator should be able to interface locally and remotely (via a communication port). Local control and indication should be included. The electrical power interfaces are described in MIL-STD-1399, Section 300A. Communication to external control and monitoring systems should be in accordance with industry methodologies and standards. Mechanical interfaces include physical mounting as well as connections to typical copper conductor cables having 90 degree C insulation systems.

The power controller should mimic the performance of electro-mechanical circuit breakers, thermal relays, fuses, and motor controllers. The function of the calibrated, resettable power controller is to: (1) operate as a configurable / adjustable / intelligent sensing device; 2) operate as a independent switching device (on/off); (3) operate as a automatic high speed (less than 8 millisecond including fault detection and interrupt time) circuit interrupter by interrupting abnormally high operating currents or short circuits; and (4) operate as a motor controller.

The control, sensing, and intelligence function of power controller is to: (1) configure the system via a control management function to allow for the switching devices to operate as multiple single pole devices, multiple two pole devices, and/or multiple three pole devices; (2) interrogate voltages and currents through the device; (3) make informed decisions based on user inputs/settings, time vs. current characteristics, di/dt characteristics (change in current with respect to time), and/or artificial intelligence techniques; and (4) provide trip commands to the interrupting device upon exceeding adjustable thresholds. Short circuit current conditions warranting an instantaneous "trip" signal to the interrupting device should be made within 7 milliseconds (design goal of approximately ½ 60 Hz cycle) of the fault inception. Adjustable thresholds include: (1) continuous current operation (adjustable from 0.1 to 50 amperes); (2) instantaneous current trip (adjustable from 1 to 1500 amps); (3) short time current trip (adjustable 1 to 1500 amps); (4) long time current trip (adjustable, 100% to 125% of continuous current setting;

and (5) adjustable time delay to prevent nuisance tripping or improve coordination with other devices (such as 30 to 120 milliseconds with +/- 5 millisecond tolerance). The unit must be capable of operating in overcurrent conditions, not be affected by non linear loading conditions (including 6 pulse rectified loads) and preventing nuisance tripping upon power up conditions (such as inhibit temporarily the instantaneous trip function on a power controller "turn on", or inhibit function when no or low current has been present but an inrush of current is sensed indicating a remote device being turned on).

The switching device function is accomplished through the use of multiple single pole solid state devices nominally rated at 50 amps continuous operation at 50 degrees C without overheating. The device should have an endurance and a reliability that exceeds circuit breaker and contactors of similar rating and size. Along with operation as a switch, the device should operate as a circuit interrupter.

The circuit interrupting device function should operate in conjunction with the control/sensing/intelligence function. The device should interrupt average three phase symmetrical currents up to 1500 amps (assuming an X/R value of 6.6, design goal should be 5000 amps at same X/R ratio). In later versions of the power controller, the device should also integrate motor controller functions. In the motor controller mode, the device must act as a switch (mimic a contactor), overload device (mimic thermal overload protection such as "heaters") and a short circuit interrupter (mimic an instantaneous trip circuit breaker). The device should open or close within 2 milliseconds after receipt of commanded position and open within 1 millisecond of a "trip" command. Local control (on/off/reset) and indication (on/off/trip) should be included with each power controller.

PHASE I: Develop a 125 vac/25 kVA/60 Hz power panel having the innovative design features of completely solid state components, fault tolerant, self diagnostic, low total ownership cost, reliable, maintainable, testable, producible, and based on open systems designs/architectures. In Phase I, develop a detail design (to meet shipboard environmental conditions) of the power panel complete with enclosure, backplane, thermal management, power supplies, circuit interrupting devices, and associated operator interface, and monitoring/control hardware/software. Prototype panel will be fabricated and tested to demonstrate concept feasibility and demonstrate 60% to 80% reduction in short circuit fault detection and interruption time when compared to comparable electro-mechanical circuit breakers. Suggested maximum width should be 15 inches (if practicable). Total volume should be minimized (existing panels are approximately 1900 cubic inches). Total weight should be minimized (existing panel and breakers are approximately 40 pounds total). Fabrication of equipment should include a modular power panel assembly that consists of field replaceable power controller, an enclosure, backplane, field replaceable power supply (for local "house keeping") and operator interface. The power controller should be set of a minimum of three (3) solid state components acting as a single pole device. These three components could be mounted to circuit card assemblies or equivalent. The circuit card assemblies would include the control, power management, and intelligence. The card would be stiffened, would include a back mounted connector that mates to the backplane, have a thermal management interface, and have a mechanical interface with the enclosure. The enclosure should house all associated components (including at least 3 power controllers), allow for mechanical/electrical input and output power connections, allow for remote control via communication port(s), have a mechanical interface to allow for mounting on a wall or bulkhead, and utilize appropriate thermal management techniques. The backplane, mounted within the enclosure, could use advanced bus bar techniques to provide power distribution and circuit interrupter device control connections. The backplane should demonstrate significant advantages in integrating external connections, integrating internal connections, and providing the power controller device interface. A power supply (with a minimum of stored energy to ride through source disturbances) and operator interface to allow for local operation and settings should be provided. The Phase I final report should include an assessment of cost.

PHASE II: Develop nominal 10 circuit, 450 vac/100 kVA/60 and 400 Hz power panel complete enclosure, back plane, thermal management, power supply, integral circuit protection/interrupting/motor starting devices, and associated operator interface, and monitoring/control hardware/software. Interrupt device rating should be increased to interrupt 5000 amps average three phase symmetrical(assuming X/R of 6.6, design goal should be 13000 amps at same X/R ratio). A neutral bus capability should be added to demonstrate 208 volt, 4 wire applications. Total volume should be minimized (existing panels are approximately 2500 cubic inches). Total weight should be minimized (existing panel and breakers are approximately 68 pounds total). Prototype panel will be fabricated and tested to demonstrate concept feasibility. Demonstrate further reduction in short circuit detection and interruption time. Determine the survivability, reliability and reusability characteristics. The Phase II final report should include an execution plan for Phase III, including cost and schedule.

PHASE III: Demonstrate producibility and develop an implementation plan for new production and replace via new design/retrofit application.

COMMERCIAL POTENTIAL: The commercial derivative of the power panel could be developed to support residential, light industrial, aircraft, and pleasure craft applications.

KEYWORDS: Electrical Power; Electrical Distribution; Electrical Protection

N01-125 TITLE: Scale Prevention in Seawater and Freshwater Flushed Shipboard Sanitary Waste Systems

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID, PEO Aircraft Carriers

OBJECTIVE: To develop an innovative system or product that can be used to alter or otherwise change the character of flushing water (seawater and freshwater) supplied to shipboard urinals and water closets, in both gravity flush and vacuum flush systems, to reduce scale build-up in collection piping. The performance of the system or product shall be such that no more than 1/16-inch of scale build-up forms in the sanitary waste system piping within a period of six (6) months. To ensure the ability of ships to discharge sanitary waste overboard is not impacted, the system or product shall not significantly change the character of the sanitary waste effluent discharged overboard (i.e. pH and biodegradability) from that of existing ship generated sewage waste. The system or product shall be compatible with the sanitary waste piping systems (Military Specification MIL-T-16420K (SH) and Military Standard MIL-STD-278F(SH) apply) or its components such as valves (Military Specification MIL-V-24509A applies), cast bronze fittings (ASTM B 61-93 applies), and sewage pumps (Military Specification MIL-P-24475 (SHIPS) applies).

DESCRIPTION: Scale build-up in sanitary waste collection piping on Navy ships is a significant maintenance burden on ship's force and shore maintenance activities. Scale forms in both gravity (seawater flush) collection, holding and transfer (CHT) systems and vacuum (fresh water flush) CHT systems. The scale has to be hydroblasted or chemically cleaned out of the piping, which is costly and time consuming. Citric acid scale prevention tablets are currently used for scale prevention. The citric acid tablet provides some relief from scale development (reducing the rate of scale development and changing the form of the scale to a softer easier to remove form), but has not completely eliminated the need to periodically clean scale from piping. In addition, the citric acid tablet is expensive (one tablet per day can be required in a high use urinal) and takes a significant amount of crew time to manually dispense.

A system or product is needed that would significantly reduce or eliminate the formation of scale in the sanitary waste drain lines on Navy ships. Both systems (mechanisms installed in the flushing water or sanitary drain system) and products (tablets, liquids, etc. to be dispensed into the flushing water or drain piping) are acceptable. However, the system or product should be effective at scale prevention, safe for Sailor use, easily dispensed (no Sailor intervention is preferred), required in a minimal quantity to save valuable storage space onboard ship, affordable, and shall not significantly change the character of the waste effluent (e.g. pH, biodegradability, etc.). The goal is to save valuable maintenance time for the Sailors and reduce or eliminate the need to clean scale.

PHASE I: Develop system or product (and dispensing system if required) that will work in conjunction with existing Navy technology to prevent scale development in the drainage piping from urinals and water closets in both gravity and vacuum sanitary systems onboard Navy ships of all sizes. The system or product should require little or no input from the crew and be long lasting so as to require little or no replenishment. The system or product should also be environmentally friendly, in that it causes no additional concerns about discharge of the resultant sanitary waste at sea or pierside. The Phase I final report should include an analysis of alternative concepts as well as an assessment of cost.

PHASE II: Conduct at sea test and demonstration, commencing with shipboard installation of the system or product on all the toilets and urinals (except those toilets and urinals designated as controls for test result comparison purposes) of an active duty Navy platform. NAVSEA PMS307 shall coordinate shipboard installation and test. This installation will be to prove that the system significantly reduces scale build-up and requires no replenishment for at least six (6) months or the time period of a Naval Aircraft Carrier deployment. The Phase II final report should include an execution plan for Phase III, including cost and schedule.

PHASE III: After verifying the effectiveness and compatibility of the system or product with Navy sanitary waste systems, demonstrate its producibility and develop an implementation plan for Fleet wide implementation of the system or product.

COMMERCIAL POTENTIAL: This technology will be applicable to any boat or ship that utilizes seawater or freshwater as a flushing medium. It shall also be applicable to both gravity CHT and vacuum CHT systems. Private boats with water closets should be able to easily install the system or product and not have to worry about scale build-up in their piping. Private shipping lines would be another potential customer.

REFERENCES:

1. OPNAVINST 5090.1B discusses the discharge requirements for sanitary waste systems onboard Navy vessels. The Navy has several documents addressing scale build-up in sanitary waste collection piping.

KEYWORDS: Scale; Sewage; Hydroblasting; Chemical Cleaning; Citric Acid Tablet; Sanitary Waste System

N01-126 TITLE: Advanced Treatment Technology for Shipboard Non-Oily Wastewater

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID, PMS 378

OBJECTIVE: To develop a system to treat shipboard non-oily wastewater and provide an effluent stream that is suitable for reuse or unrestricted discharge. The discharged effluent quality should be appropriate for unrestricted discharge in coastal waters (Biochemical Oxygen Demand (BOD5)<30mg/l, Total Suspended Solids (TSS)<30mg/l, and Fecal Coliforms (FC)<200 colonies per 100ml) which meets or exceeds the MSD requirements listed in the reference.

DESCRIPTION: Current Navy ships are designed and built with Collection, Holding and Transfer (CHT) systems that include the tankage required to hold ship-generated sewage for 12 hours. This sizing is based on the maximum expected transit time for the 3 nautical mile (nm) no-discharge, contiguous zone from shore. It is anticipated that effluent quality based on Uniform National Discharge Standards (UNDS) will require that the no-discharge zone be extended to 12 nm, and that graywater (wastewater from showers, galley, scullery, deck drains, laundry and lavatories) generated onboard be treated or held when the ship is in this zone. The holding capacity of existing ships is insufficient to meet the anticipated regulations without wastewater treatment. The most promising technology for treating shipboard non-oily wastewater evaluated to date is the membrane bioreactor (MBR). An aerobic bioreactor is used to pre-treat incoming wastewater so that in-tank membranes can separate solids, bacteria and other contaminants from the effluent stream. The MBR has limitations, including foam control, long-term membrane fouling, and the sensitivity of the biomass to chemical shocks that can occur in graywater drains. In addition, the Navy is demonstrating microwave technology for the incineration of shipboard non-oily wastewater.

An alternative non-oily wastewater treatment process that separates clean effluent from its contaminants without reliance on the MBR may provide a more rugged system that is more easily automated to satisfy reduced manning requirements. Additionally, to support the goal of an environmentally sound ship, reuse of system effluent for technical purposes such as sanitary flushing or equipment washdown would be advantageous. Non-oily wastewater potentially could include certain metals, AFFF, and machinery oils, and the treatment equipment should be capable of handling these constituents without damage to its components or violation of effluent quality limits.

PHASE I: Develop a conceptual design of a system that meets the functional requirements for wastewater treatment of typical navy non-oily wastewater (graywater plus blackwater). System should be able to meet discharge criteria for coastal waters of the U. S. In conjunction with the design, a plan for any subsequent treatment necessary for potential reuse of the treated water should be provided. Reuse would be restricted to technical purposes (i.e., sanitary flushing header, equipment washdown, etc.). The Phase I final report should include an assessment of cost.

PHASE II: Build and test a pilot-scale system that incorporates the critical technologies to prove that the conceptual design works as intended. Conduct pierside testing on actual shipboard waste streams and collect test data to accurately outline a full scale ship system design with the anticipated component sizes, weight, and power requirements, and auxiliary system interfaces. This phase will support development of full-scale equipment for a specific ship application along with the information necessary for the Navy to determine whether to move forward with this technology. The Phase II final report should include an execution plan for Phase III, including cost and schedule.

PHASE III: After verifying the effectiveness of the system and compatibility of the system, demonstrate the producibility and develop an implementation plan for fleet-wide implementation of the system or product.

COMMERCIAL POTENTIAL: This technology will be applicable to any boat or ship that requires wastewater treatment, and should prove to be very efficient from the standpoints of size, weight, and power requirements. It would also be useful in industrial applications where water reuse could increase profitability by reducing required municipality support in water supply and wastewater treatment areas.

REFERENCES:
1. OPNAVINST 5090.1B discusses the discharge requirements for sanitary waste systems onboard Navy vessels.

KEYWORDS: Sewage, Graywater, Blackwater, Treatment, Wastewater, Reuse

N01-127 TITLE: Tactical Sonar Data Fusion

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: AN/SQQ-89A(V)15

OBJECTIVE: Enable sonar analysts to review, integrate, and make rapid tactical decisions based on detection and classification information from multiple undersea warfare acoustic sensors.

DESCRIPTION: The future surface ship Undersea Warfare (USW) combat system will consist of multiple hull-mounted, off-board and towed array sensors providing inputs to multiple active and passive signal processing functional segments. Acoustic sensors will cover a frequency range of over 14 octaves and signal processing segments provide traditional acoustic displays and automated classification data from diverse USW functions, including monostatic/bistatic active, torpedo defense, passive ASW, and airborne sensors. Current implementations provide independent displays for each sensor/processing function and require the sonar analyst to manually synthesize the acoustic scene. Functional segments available for data fusion include; passive acoustic contacts, active acoustic contacts, torpedo like contacts and radar contacts. Sensors available for fusion include hull array, towed array, acoustic intercept sensor, radar, underwater phone and off-board sonobuoy sensors. This effort will develop new technologies to provide the analysts with a consolidated underwater picture of USW sensor data. Technologies that need to be developed include; drill down information/display hierarchy, radar/sonar contract fusion, novel display concepts and color mapping innovations for added operator visualization.

PHASE I: Develop a system design for consolidating acoustic displays and automated processing measurements from the full complement of USW sensors and processing functional segments. Objective of this effort shall be performed without increasing current manpower allocations or watch standers billets. At the same time, this effort needs to provide displays that our operator oriented from a geo-situational contact basis. Phase I shall define the information processing algorithms required associating data from these diverse acoustic sensors and functional segments.

PHASE II: Implement and test a prototype USW data fusion capability as described in Phase I in a laboratory environment. Demonstrate performance with recorded at-sea data from surface ship USW sensors on the prototype lab system. Compute performance metrics for the implemented data fusion and displays

PHASE III: Integrate a USW data fusion capability into the AN/SQQ-89(V) surface ship USW combat system. Install and test the real-time prototype system on a grey boat as directed by PMS 411 for at-sea test.

COMMERCIAL POTENTIAL: This system could be applied in any complex system that requires analyst to merge data from multiple detection or imaging sensors.

KEYWORDS: Automation, acoustic sensors, information processing, real-time, fusion, and sonar

N01-128 TITLE: Novel Approaches for Automated Information Processing of Active Sonar Data

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II, AN/SQQ-89A(V)15

OBJECTIVE: Investigate and develop new automation techniques for the analysis of active sonar matched filter data to discriminate target returns from clutter.

DESCRIPTION: A crucial problem in active sonar is discrimination of targets from clutter, especially in littoral regions which have many confusable features. The receiver function that facilitates target identification, typically following beamforming and matched filtering, is referred to as Information Processing (IP). Even systems with large transmitter source level, extensive bandwidth, or high gain receive arrays cannot be effective without a reliable IP function. Active information processing in past systems has been primarily focused on parameterized methods measuring features within the matched filter, or threshold crossing data, or tuned neural networks.

New active information processing methods are sought for automation and clue processing of active return data from low speed targets in littoral environments. R&D innovations are specifically needed to deal with the technical uncertainties of bistatic and multi-static systems now in development. There is a need to reduce the technical risks associated with these types of systems due to complex acoustic propagation, bottom interaction, waveform distortion, and loss of signal coherence due to multipath. . As indicated in the references, a significant R&D challenge is false alarm reduction. The littoral environment presents the further complications of convolved noise and non-stationarity, for which optimum processing solutions are not available in the literature. Technical parameters of interest are: operating frequency bands of 50 to 6000 Hz, Doppler processing for target speeds from 0-10 knots, waveform types including continuous wave and swept frequency modulation, sensor types including hull-mounted and towed arrays with up to 400 sensor channels.

Offerors should propose novel information processing approaches which would specifically reduce the technical risks presented by low Doppler target processing in littoral areas. Proposed techniques should be theoretically well founded and show feasibility

for robust performance across the range of Navy sonar operating environments, without extensive tuning or reliance on frequent operator adjustment. Proposed algorithms must be capable of running effectively in real-time on modern processors. IP processing techniques for low and middle frequency, and proposed wide bandwidth systems are of interest.

PHASE I: Develop and describe the theory and proposed implementation of the selected information processing algorithms. Demonstrate prototype processing on synthetic data. Develop computational timing and sizing metrics and sonar performance metrics for the implemented algorithms.

PHASE II: Implement the proposed algorithms in a lab environment. Conduct processing on sea data from active systems (to be provided by the Navy). Compute performance metrics for the implemented algorithms.

PHASE III: Implement the successful information processing algorithms for real-time execution in a fielded system. Install and test the real-time prototype system on a Navy-specified platform for at sea testing.

COMMERCIAL POTENTIAL: Commercial acoustic imaging sonar suffer the same requirement to discriminate targets from clutter. The results of this task could vastly improve fish-finding sonar, sub-bottom sediment classifying sonar, bathymetry swath sonar, buried object detection sonar, and harbor survey sonar.

REFERENCES:
1. Stanton, T.K., Acoustic Classification of Irregular Bodies, Woods Hole Oceanographic Inst., 1996, (NTIC AD-B206 613L).
2. Coon, A.C., Survey of Classification Techniques for Impulsively Activated Sonar System with Applications to Extended Echo Ranging (EER) and Improved EER (IEER), Johns Hopkins University, Applied Physics Lab., Aug. 1996, APL90-20595-013 (NTIC AD-C057 339).

KEYWORDS: Active sonar; Signal Processing; Real-Time; Information processing; Algorithms; Underwater Acoustics

N01-129 TITLE: Thermal Stress Management of Infrared (IR) Windows

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMS 422 (Standard Missile)

OBJECTIVE: Develop technologies that reduce or eliminate aerodynamic heating of optical windows used in conjunction with passive IR detectors.

DESCRIPTION: The passive IR homing systems used for certain missile systems usually observe the outer environment through a protective window. Since these IR homing systems tend to be at the tip of the missile, the protective windows undergo aerodynamic heating as missile flight velocities increase. The elevated window temperatures can range from 5° to well over 100° C above ambient and introduce noise into the IR sensor, often corrupting its performance. The Navy is seeking technologies to prevent or negate this heating effect. Innovative adaptations of existing technologies or new technical approaches are needed to minimize the influence of the protective window on IR sensor performance. The Navy is seeking to apply this technology to both passive and active sensor/seeker systems for missiles and satellites so volume, weight, reliability and power requirements are a concern.

PHASE I: Develop concepts and design approaches that provide appropriate thermal control to IR windows to meet nominal sensor system requirements. Fully describe the theory of operation of the concept or approach. Provide a detailed description of the technology concepts and/or materials that prevent or negate window heating. Provide analysis showing concept performance characteristics and limitations.

PHASE II: Design, build and test a prototype system based on the technology products of Phase I. Based on the nominal IR sensor used in Phase I, show the ability to render the protective window to a useful, non-disruptive status at velocities of Mach 1, 2, and 3 (1000 ft. altitude, 1976 Standard Atmosphere). Show how the design might perform for alternative window profiles relative to thickness and shape (such as spherical, conical or flat) based on projected steady-state aerodynamic effects.

PHASE III: Depending upon Phase II results, transition to advanced development of a full-up design and production package.

COMMERCIAL POTENTIAL: Passive IR sensors are seeing increased application in commercial transportation. High speed private/corporate jets and space launch/reentry vehicles are a potential market.

REFERENCES:

1. Analytical method to calculate window heating effects on IR seeker performance: (SPIE Proceedings Vol. 2286 Paper # 2286-58)
2. By E.F. Cross (EFC Research Associates, Los Angeles, CA)
3. Infrared Window and Dome Materials (Tutorial Texts in Optical Engineering ; V. Tt 10) by Daniel C. Harris. Paperback (July 1992)
4. Window and Domes Technologies and Materials III (Proceedings of S P I E, Vol 1760) by Paul Klocek(Editor). Paperback (December 1992)

KEYWORDS: IR Window; Seeker; Sensor

N01-130 TITLE: Integrated Underwater Sensing System for Platform Safety & Threat Alertment

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PEO Mine Undersea Warfare (MUW)

OBJECTIVE: Conceptualize, develop and demonstrate a scaleable and modular integrated underwater sensing system, which can ultimately be adapted for installation aboard ships of any size for protection against navigational hazards, combatant and terrorist threats. The system will be able to automatically detect and warn of natural, man made, and human threats to ships navigation and safety. Explore techniques to detect, identify and provide alertment for hazards to transit operations, amphibious operations, and in-port scenarios. Develop software algorithms to distinguish actual environment from threat features. Investigate the integration of multiple ship functions and develop capability to scan immediate underwater battlespace for threat features, asymmetric threats, natural hazards, obstacle hazards and mine threats. Method of detection and reporting may be based on existing or emerging technologies.

DESCRIPTION: Accurate and reliable underwater sensing, interpretation, and display are critical to Ships safety both underway and in port. These critical measurements must be made with the range of constraints of the open ocean and near shore (littoral) environments. System design must overcome technical challenges such as: 1) environmental effects (temperature and salinity changes, biofouling, turbidity, corrosion), 2) interference from ship's own electronics and sonar, 3) signature detectability and discrimination of natural, man-made, and human entities, 4) calibration, servicing and mounting methods. In addition to these design considerations, the integrated underwater sensing system must also provide a) automatic alerts, b) accuracy and resolution to allow for appropriate and timely ships actions, c) functionality during transit, maneuvering, and dockside operations, and d) scalability for installation on all ships. Because of the existing and evolving need for this capability, the possibility for rapid development and production is desired.

PHASE I: Develop proof of concept designs of the integrated underwater sensing system based on current COTS available technology. Cost would include engineering design of prototype, schedule for prototype production and delivery for testing, and development of a test program to demonstrate critical functional design capabilities. The concept development plan shall include a detailed analysis of logistics functions and costs, and proposals for Total Ownership Cost (TOC) reductions. Total Phase 1 cost is estimated to be $70K.

PHASE II: Develop prototype system and demonstrate proposed functionality against navigational, terrorist, mine, and littoral obstacle threats. Develop well-defined plans for prototype installation onboard a Fleet representative test platform and conduct evaluation testing. Data collection and analysis methods must be identified. Develop a streamlined through-life logistics plan that maximizes effective logistics at minimum cost by innovative structuring of work division between industry and government (best value). Engineering design will address scalability of functions to meet needs of various Military and Commercial Vessels. Cost to procure prototype system including remote readout and control at underway bridge station and inport quarterdeck area is estimated at $700K for system development, installation and logistics planning, and testing. The ultimate target price of a production system is estimated at $175k or less per unit. A testing plan will be developed to test the IUSS's capabilities against four specific scenarios; forward looking navigational hazards and bottom depth sounding/profiling while underway; underwater swimmer detection; small boat approach evaluation while moored pier side and at anchorage. Actual test execution will occur on the NUWC Division Keyport Ranges leveraging from USN Ships assets. Data will be collected using Windows based programs and stored on the hard drive of a lap top computer. Analysis will consist of comparing bottom profiles with know contours in the Puget Sound Basin. Data will be time and GPS synchronized to ensure accuracy of comparison. Static (pierside/anchored) testing analysis will be made against real time "battle problem" detailed in the test plan. Initial detection will be along known lines of bearing progressing to "weapons free" threat introduction from any quarter.

PHASE III: Transition final design data to production of an integrated underwater sensing system that provides depth sounding, underwater threat detection, and hazard avoidance capabilities. Transition capability as a replacement for the AN/UQN-4 Depth-Sounding Fathometer and adapt final design to backfit systems on commercial and military platforms.

COMMERCIAL POTENTIAL: Such a system could be used by commercial Cruise Ship, Ferries, Freighters, Oil Tankers, and other commercial vessels to assist in safe navigation of restricted waters and warn of potential underwater threats. Other potential applications would aid commercial dredging, cable laying, and bottom survey operations.

REFERENCES:

1. AN/UQN-4 Depth-Sounding Fathometer technical specifications

KEYWORDS: Depth Sounder; sonar; counter-terrorism; mines; obstacle avoidance; swimmer detection

Office of Naval Research (ONR)

N01-131 TITLE: Multiple-Beam Electron Gun for High Power Amplifiers

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop a low voltage multiple-beam electron gun for a high power multiple-beam amplifier (MBA) operating in S-band. MBAs are a device technology with the potential to provide the increased bandwidth, high average power, and low-phase-noise performance required by shipboard radar to keep pace with evolving anti-ship cruise missile (ASCM) and tactical ballistic missile (TBM) threats.

DESCRIPTION: The main focus of the development is multiple-beam generation and transport. Previous work in the FSU has concentrated on low-convergence guns resulting in high cathode-loading (>15 A/cm2) and relatively short operational lifetimes. This development will explore more highly convergent multiple-beam gun designs using the 3-D electron gun code, MICHELLE (ONR-funded), to reduce cathode loading below 10 A/cm2, improving operational life. The magnetic circuit will be designed using a commercial package, such as MAXWELL 3-D. A beam analyzer will be fabricated to validate the gun design and beam transport system.

PHASE 1: Initial design of a multiple-beam gun using 3-D design tools such as the Gun/Collector code MICHELLE (supplied by the government at no cost), and a 3-D magnet code, such as MAXWELL3D.

PHASE II: Design and demonstrate a multiple-beam (no less then seven beamlets) electron gun capable of generating total of 1.5 megawatts of beam power, with a cathode loading consistent with SPY-1 application lifetimes. Demonstrate 98% beam transmission through each individual beamlet channel.

PHASE III: Integrate the electron gun with the other components of the S-band MBA in collaboration with naval researchers.

COMMERCIAL POTENTIAL: Commercial applications of multiple-beam amplifier technology include broadband high power amplifiers for commercial satellite uplinks and high-energy accelerators, where the low operating voltage is attractive due to reduced costs and increased reliability.

REFERENCES:

1. E.A. Gelvich, et al, "The new generation of high-power multiple-beam klystrons," IEEE MTT Transactions,41, 15-19 (1993).
2. L.M. Borisov, et al, "High-power multi-beam vauum microwave amplifiers," Elektron. Tekhnika, Ser. 1, Elektron.SVCh, No. 1, 12-20 (1993) (in Russian).
3. C. Bearzatto, A. Beunas, and G. Faillon, "Long pulse and large bandwidth multibeam klystron," paper presented at the RF-98 Workshop, Pajaro Dunes, CA, October 1998.
4. Y. Besov, "Multiple-beam klystrons," paper presented at the RF-98 Workshop, Parajo Dunes, CA, October 1998.

KEYWORDS: electron gun, multiple beam, multiple beam amplifier

N01-132 TITLE: Low-cost. Lightweight, Mid-Wave InfraRed (MWIR) Sensors

TECHNOLOGY AREAS: Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: AAAV(Advanced Amphibious Assault Vehicle)

OBJECTIVE: Develop and demonstrate a camera operating with a one-stage thermoelectric cooler capable of fast photoresponse in the 3-5 micron waveband.

DESCRIPTION: Current technology for detection of ordnance, gunfire, rocket plumes and fires involves the use of cryogenically-cooled cameras in the Mid-Wave InfraRed (3-5 microns wavelength) spectral band. These sensors use InfraRed Focal Plane Arrays (IRFPA's) that operate between 70 K to 130 K temperatures, depending on the material and may consist of either single-color or multiple-color approaches. These cooled IRFPA's have been able to make successful technology demonstration sensors; however, they are expensive (of the order of $100,000 / camera) and bulky (typical weights of 5 pounds for a militarized cooled MWIR camera). This makes them unaffordable and impractical for many Marine Corps and Naval applications. Such system applications include self-defense/situational awareness/warning sensors of expeditionary and land-warfare craft such as AAAV, LCAC, and HUMMWV; low-cost, lightweight Unmanned Aerial Vehicles (UAV) sensors; and individual infantryman systems. The goal of this SBIR is to develop technology for cameras which would be an order of magnitude cheaper and lighter than the current generation of MWIR camera. The largest R&D risk factor is the MWIR IRFPA.

PHASE I: Develop a conceptual design of a MWIR IRFPA (detectors and readout) with approximately a 256x256 format, 60Hz (or greater) frame rate, and pixel sizes of approximately 25 - 50 microns (less is preferred). Detectivity D* should be 1E10 Jones or greater at an operating temperature that can be provided by a low-cost, low-power thermoelectric cooler.

PHASE II: Fabricate, test, and deliver a prototype camera using a narrow band (0.1-0.2 micron wide waveband suitable for plume detection) MWIR IRFPA based upon the design in Phase I. Because the emphasis will be on IRFPA development, camera Field of View is flexible - it should be somewhere from 30 to 95 deg x 30 to 95 deg. Assess applicability and extension of the technology to multispectral IRFPA's.

PHASE III: Demonstrate low-cost producibility and develop an implementation plan for large scale production of cameras (under $10,000 / unit goal for > 300 cameras/year production). Demonstrate successful lightweight (under 1 lb.) cameras and/or multispectral versions of the MWIR IRFPA cameras for military and commercial applications.

COMMERCIAL POTENTIAL: The manned land/sea/air vehicle, UAV, and infantry military market for such sensors could be in excess of 1000 cameras per year. Additional applications such as spectroscopy, remote sensing, medical imaging, firefighting, police/border patrol, and other government/commercial/scientific applications could have a market of tens of thousands/year. As camera costs drop, the market for such devices is likely to expand rapidly.

REFERENCES:

1. S. Jost et al, "Room Temperature MWIR FPA's - Return of the Lead Salts?", Proceedings of the 1999 MSS/IRIS Conference on Infrared Detectors, published by Veridian/ERIM International, 1999

KEYWORDS: Infrared cameras, electronic warfare, detectors, detection

N01-133 TITLE: Maritime Intelligence, Surveillance, Reconnaissance (ISR) and Space Exploitation

TECHNOLOGY AREAS: Battlespace, Space Platforms

OBJECTIVE: Further the development of technology to automatically develop complete awareness of the littoral maritime situation long before, leading up to, during, and after military engagement.

DESCRIPTION: The focus of this SBIR topic is to stimulate bold new concepts for significantly increasing the performance of automated maritime ISR including use of space assets. The Century 21 Navy will need complete awareness of the sub-surface, and surface situation within a wide area of interest. This SBIR focuses on the littoral situation, which is complicated by the presence of many neutral surface ships of all sizes and purposes as well as friendly and enemy combatants, including mines. Awareness must extend seamlessly across time, beginning well before and extending through hostilities. Situation Awareness must be consistent among all involved. Situation Awareness will be expressed in the form of a complete picture of who is where as a function of time. This picture will be available to all Naval personnel at an appropriate level of resolution. This SBIR focuses on aspects of maritime ISR other then conventional ASW and MCM since these are covered by other SBIR topics. Novel means of exploiting existing sensors, including space sensors are of interest. Methods of detecting and classifying (or, in some cases, identifying) neutrals (commercial shipping, fishing and pleasure craft) and unusual threats such as small surface craft (i.e. "Boghammers") and small submarines (diesels or mini-submarines) are of interest. Examples include but are not limited to: 1) surface ship surveillance exploiting ship acoustic, electromagnetic, or hydrodynamic signatures or use of GPS signals or low resolution space based radar to illuminate the ocean surface; 2) undersea surveillance via fusing of passive acoustic and non-acoustic sensing. Methods of tracking entities of interest in the complex littoral environment are sought. The littoral scene may contain many objects with crossing paths and unknown motion models. Methods of maintaining a consistent awareness of the situation among Navy personnel who are dispersed and intermittently in contact with each other are sought.

PHASE I: Develop a complete algorithm or detailed description of the proposed ISR concept. If the concept involves hardware produce a design. This algorithm, description, or design and supporting documentation should be sufficient to convince qualified engineers that the proposed concept is technically feasible.

PHASE II: Produce and demonstrate performance of a computer program based on the algorithm or description of the concept. If the concept involves hardware, produce and demonstrate performance of an eXploratory Development Model (XDM). Demonstrate performance in such a way as to convince qualified engineers that the proposed concept is capable of meeting requirements in an operational environment.

PHASE III: Team with the manufacturer of one of the Navy's ASW or MIW ISR systems to integrate the concept into future generations. Team with manufacturers of commercial fusion systems, such as air traffic or harbor control, to integrate the concept into these products.

COMMERCIAL POTENTIAL: There is a commercial market for ISR concepts applied to air traffic and harbor control. There is a growing commercial market in tracking littoral traffic for law enforcement (smuggling and illegal fishing).

REFERENCES:

1. Waltz, Edward and James Llinas, "Multisensor Data Fusion," Artech House, 1990, Bar-Shalom, Y., "Tracking Methods in a Multitarget Environment," IEEE Transactions on Automated Control, Vol. AC-R3, August 1978, pp. 618-626

KEYWORDS: Electromagnetic, Acoustic and Hydrodynamic signatures, multitarget tracking, state estimation, common tactical picture

N01-134 TITLE: Component Level, Multimedia communication technology for survivability

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate a dual mode, device level, media communication capability for twisted pair and RF wireless communication, based on the ANSI/EIA 709.x Protocol (commonly known as Lontalk). This technology will enable devices on a twisted pair, distributed control network that have been isolated from the network, due to damage, to reestablish communication via RF transmission.

DESCRIPTION: The Navy has developed an affordable survivable component level intelligent distributed control system architecture for shipboard automation. This architecture employs the ANSI/EIA 709.x Protocol in a dependable topology with embedded online reconfigurability to monitor and detect damage to the twisted pair network and heal network fragments. The dependable topology consists of a partial mesh of rings. Routers interconnect the rings. The component level networks feed into ship-wide area networks. The component level networks consist of intelligent devices that may require communication across the network to perform at full capability (normal operations, casualty control, and damage control). Since twisted pair communication speed and bandwidth exceeds RF speed and bandwidth it is expected that the primary communication medium for these shipboard control networks will be twisted pair. With the Navy's unique requirements for survivability these systems need to be designed for the potential destruction or interruption of the control networks. Therefore, RF wireless communication will be required, as a backup medium, to maintain critical functionality between the devices in the system. The backup device must either be part of the device or co-located with the device. The backup RF connection must allow network communications with the device to dynamically switch from one media type to the other, dynamically reestablishing its identity, functionality, and logical network variable connections on the network. Failures to the twisted pair should be readily isolated from the RF connection.

PHASE I: Perform a tradeoff study that compares wireless bandwidth capacity and cost, and recommend an approach for an affordable backup wireless communications capability. Consider embedded and co-locatable approaches. Proceed to develop a preliminary design of the recommended dual mode (RF-twisted pair) media interface for ANSI-709.1 networks and demonstrate its conceptual feasibility.

PHASE II: Develop the Detailed Design of the dual mode (RF- twisted pair) media interface and demonstrate the RF backup functionality in a live network through the loss of its twisted pair communication interface.

PHASE III: Initiate Low Rate Production of the dual mode (RF-twisted pair) media interface and potential joint development projects with the U.S. Navy Surface Warfare Systems Group

COMMERCIAL POTENTIAL: Multimedia controllers will have great potential in commercial automation systems where continuous availability is important such as production, fire or security system

REFERENCES:
1. Adept Systems Inc. "Self Healing Component Level Intelligent Distributed Control Networks for controllers will have great potential in commercial automation systems Survivable Shipboard Automation Infrastructure" 15 September 2000
2. Analysis and Technology, an Anteon Company "Network Fragment Healing Demonstration Test Procedures" 13 July 2000

KEYWORDS: Component Level, Dual Communication Media, Survivability

N01-135 TITLE: Boost-Phase Sub-Unit Vaccine Development for Binary Vaccines Against Infectious Diseases and Biological Warfare Agents

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: This topic requests the development of a vaccine platform using a recombinant virus and/or viral-like particle to express foreign antigens. The viral platform must be immunogenic but safe for use in humans.

DESCRIPTION: Current human vaccines use multiple doses of the same vaccine to immunize against toxins or pathogens. These vaccines work primarily by inducing neutralizing antibodies, but are not very effective at stimulating T cells to kill invading micro-organisms. Though successful in preventing many human diseases, such unitary vaccines have failed to protect against HIV, TB, and Malaria, which have been designated by the National Security Agency and the President as threatening our national security. They have also proven inefficient in providing immunity to many potential biological warfare agents. Anthrax, requiring a complicated and lengthy immunization schedule, is one such example. Recent animal vaccine literature demonstrates that a two stage vaccine, in which the first dose consists of DNA vaccine and the second dose uses a recombinant, attenuated virus, provides a potent immune responses. However, such immunization strategies using virus or virus-like particles in the boost phase have not been tested in humans because of concerns about safety. The research component of this Topic would consist of selecting and engineering one of many possible viral systems to have the dual characteristics of safety and high immunogenicity. Successful preclinical development of such a viral vaccine would lead to a platform technology for development of vaccines for a large number of emerging disease or biological warfare threats.

PHASE I: Develop a prototype viral based vaccine platform predicted to have the required safety and immunogenicity characteristics. As a proof of principle, insert selected proteins from malarias pathogenic to animals into the platform virus. Produce enough of these constructs under research grade conditions to test in-vitro expression of malaria proteins and immunogenicity and protection against malaria infection in mice and monkeys. This viral construct will be tested alone and in conjunction with existing DNA vaccines expressing the same malaria antigens.

PHASE II: Produce a viral vaccine expressing antigens from the human malaria P. falciparum under GMP-like conditions. These constructs would form the basis of a viral vaccine against malaria for use in humans. Sufficient vaccine will be produced to demonstrate in-vitro expression of proteins and for testing of immunogenicity in animals. This viral construct will be tested alone and in conjunction with existing DNA vaccines expressing the same malaria antigens.

PHASE III: Demonstrate the ability to manufacture the viral falciparum malaria vaccines under GMP conditions. This product and supporting data should be of high enough quality so that it would meet standards for submission to the FDA for human testing.

COMMERCIAL POTENTIAL: A successful viral vaccine incorporating the attributes desired in this Topic would have profound commercial applications. The viral platform could be used to develop vaccines against many pathogens for which adequate vaccines do not exist.

REFERENCES:
1. Sedegah M, Jones T, Kaur M, Hedstrom R, Hobart P, Tine J, and Hoffman SL. 1998. "Boosting with recombinant vaccinia increases immunogenicity and protective efficacy of malaria DNA vaccine". Proc. Natl. Acad. Sci USA, vol95, pp7648-7653.

KEYWORDS: Vaccines; Immunology; Heterologous; Prime-Boost; Infectious Diseases, DNA.

N01-136 TITLE: Digital Cellular-Phone Transceiver-based Foliage Penetration Interferometric SAR for EO/IR Sensor Fusion ATR

TECHNOLOGY AREAS: Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVSEA PMS-529

OBJECTIVE: Develop inexpensive digital cellular-phone transceiver-based foliage penetration interferometric SAR to be fused with IR hyperspectral imagery for terrain map navigation and for automatic target recognition (ATR) suitable for UAV operation.

DESCRIPTION: In principal dual frequency interferometric SAR can provide terrain elevation capability for correlation with digital maps for terrain navigation. It should be compatible with low cost digital cellular-phone transceivers with arbitrary waveform generation to transmit message/image data. It is anticipated that the early digitization at the transceiver array will provide at least 100 dB high dynamic range for foliage penetration, 3D imagery, and communication applications. Furthermore, digital FOPEN interferometric SAR 3D terrain imagery can be combined with IR hyperspectral imagery to provide detailed target characteristics needed for ATR.

PHASE I: Provide system and component design of all digital FOPEN interferometric SAR at UHF & VHF dual frequencies in order to meet the requirements of a low-cost device capable of UAV targeting and navigation.

PHASE II: Develop and demonstrate a working prototype digital FOPEN interferometric SAR system.

PHASE III: Applications of digital FOPEN interferometric SAR should include NAVSEA gun-launched UAV.

COMMERCIAL POTENTIAL:
Law enforcement agency requires a high dynamic range and inexpensive FOPEN radar for ground surveillance. This SBIR will have transition to commercial sale to police, drug enforcement agency, NASA resource management, and forest fire fighting.

REFERENCES:

1. "Radar 2000" IEEE Conference Proceedings, Szu et al. "Commercial Application of Digital Radar", May Washington DC.
2. Digital Array Radar Volume Search Radar, ONR Code 313 Web page

N01-137 TITLE: Expeditionary Logistics

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Use logistics modeling and simulation to establish a qualitative and quantitative disciplined approach to weighing technology focus areas against the larger Naval expeditionary logistics mission. Rapidly define the greatest return on investment for needed capability or requirement in the overall acquisition investment strategy.

DESCRIPTION: Setting requirements and acquisition priorities within the Naval logistics community is a challenge. The systems engineering aspect of Naval operational logistics, and the benefit of a logistics simulation in this area, has proven a complex and challenging problem. The wide variety of variables which must be considered complicates the problem set-up and problem solving environments. Today's tools are varied. There are engineering level models that successfully model characteristics of a piece of equipment and its performance, but these tools do not model the equipment against its purpose. Today's system design evaluation models include many pieces of equipment and govern their interaction, but as the system grows larger (such as Naval logistics) the model either becomes too complex to be employed effectively by the discreet program offices or provides poor resolution in the solution set. A final model type, the battle outcome model, takes into account equipment, troops and doctrine, with simulated interaction between competing forces and survivability of troops and equipment. While this is a useful operational environment, the assessment method of battle outcome wargaming does not take into account the robust variable set that the acquisition community must consider when constructing the analysis of alternatives. Within this proposed development, the end capability should be a tool to help the Naval community understand in context the implications of logistics on new tactics, techniques and procedures. But additionally the tool will assist technologists and acquisition professionals focus resources on the critical drivers (both operationally and at the equipment characteristic level) in supporting the Naval logistics mission profile demands effectively and efficiently.

PHASE I: Modeling parameters, metrics and architecture will be defined. Key technology enablers will be explored and addressed in risk reduction fashion. A balanced matrix allowing dissimilar systems and the dissimilar metrics of operations vice acquisition to be compared will be addressed.

PHASE II: Conduct Model Development. Proposal will address verification and validation plans, data sources, and incremental measures of success/progress that afford the government opportunity for earned value management.

PHASE III: There will be numerous opportunities for follow-on R&D through continuous programmatic coordination with the requirements, doctrine and acquisition communities which will benefit from this tool suite.

COMMERCIAL POTENTIAL: Each of the areas of combat service support are represented in the private sector. Such technological advances in smart buying tools, information management and decision support have substantial marketability.

KEYWORDS: Naval Logistics, Acquisition, Doctrine, Modeling, Metrics

N01-138 TITLE: A Self-Contained Solar Radiation Measurement Package for an Aircraft

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a stand-alone instrument package for measurement of spectrally resolved up- and down-welling solar fluxes and optical depth from an airplane or other moving platforms.

DESCRIPTION: Solar flux measurements from an aircraft require corrections that account for platform attitude and orientation, among other things, and therefore require synchronization and assimilation of data measured by other independent systems. In this development, all sensors needed to provide spectrally resolved fluxes and optical depths should be integrated into one stand-alone system. For example, the radiation sensors might be mounted along with an attitude sensor on a feedback-controlled platform, such that sensor's orientation is actively maintained independently of the aircraft's orientation. Similarly, the optical depth system, whether it is a sun photometer or a shadow-band radiometer should be self sufficient and independent of auxiliary payload measurements. Consideration should be given to miniaturizing the sensors. The primary aircraft is a Twin Otter, but the package should be transferable onto other aircraft. Power for the instrumentation will be provided from the aircraft's 28V DC generators, and data from the instrumentation should be passed to the aircraft's data system. Consideration should be given to minimizing both size and power requirements.

PHASE I: Design a prototype system that can independently do solar radiation measurements from a research aircraft.

PHASE II: Develop and demonstrate a fully capable radiation instrument for use on a research aircraft. Develop commercialization (Phase III) plans, including descriptions of specific applications, potential customers, proposed demonstrations, and transition efforts to be performed.

PHASE III: Replace or modify prototype for a specific application or product.

COMMERCIAL POTENTIAL: Benefits to researchers and to research or monitoring programs are inherent in the objective of the proposed effort. Existing systems rely on data from other measurement systems and large effort in synchronizing and assimilating unrelated measurements to arrive at accurate radiation data. This stand-alone package will provide engineering data in real time, and grossly reduce both time and manpower requirements. The package will benefit ship and aircraft based research, and also, in a simpler version (without orientation feedback controls), land based programs.

REFERENCES:

1. Livingston, J. et al., Shipborne sun-photometer measurements of aerosol optical depth spectra and columnar water vapor during ACE-2, and comparison with selected land, ship, aircraft, and satellite measurements, Tellus (2000), 52B, 594-619. (See also references therein).
2. Formenti, P. et al., Measurements of aerosol optical depth above 3570m asl in the North Atlantic free troposphere: Results from ACE-2. Tellus (2000), 52B, 678-693.

KEYWORDS: Real-time Data Collection; Data Management; and Instrument

N01-139 TITLE: Smart Low Altitude Platform for Atmospheric Measurements from a Research Aircraft

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a capability to tow a smart instrument package bellow a research aircraft and have it stabilize at a specified altitude. The smart package should be able to ``fly" while towed at a fixed height above the sea surface.

DESCRIPTION: The ability to tow a stabilized smart instrument package bellow a research aircraft opens up a number of possibilities to answer fundamental operational and research questions about the surface flow over the ocean. The smart package should be able to ``fly" while towed at a fixed height above the sea surface. The operational area of interest for the smart instrument package is the region below 30 meters, which is characterized by high atmospheric gradients. The lowest altitude research aircraft currently operate is usually no lower than 200 meters. There should be space in the smart tow package for instrumentation to include air temperature, humidity, turbulence, and aerosol sensors. Power for instrumentation and smart tow vehicle systems should be provided from the mother aircraft. Data processing and storage for the instrumentation and smart tow

vehicle automated flight control systems should also be provided from the mother aircraft. The smart tow vehicle system should be able to be The package should be designed so if it hit the ocean it would not damage the mother aircraft. The system solicited here should be compatible or scalable with a verity of aircraft sizes and types, but operation from small twin-engine aircraft is required.

PHASE I: Design a prototype system that can support low altitude (20-meter) atmospheric measurements from a research aircraft.

PHASE II: Develop and demonstrate a fully capable smart tow vehicle system for use with a research aircraft. Develop commercialization (Phase III) plans, including descriptions of specific applications, potential customers, proposed demonstrations, and transition efforts to be performed.

PHASE III: Replace or modify prototype for a specific application or product.

COMMERCIAL POTENTIAL: Benefits to researchers and to research monitoring programs are inherent in the objective of the proposed effort. Commercial applications include oil spill assessment and mineralogical assessment.

REFERENCES:

1. Edson, JB and CW Fairall 1998: Similarity relationships in the marine atmospheric surface layer. J. Atmos. Sciences, vol 55, 2311-2328.

KEYWORDS: Marian Atmospheric Boundary Layer, Surface ducting, optical propagation, atmospheric measurements, and aircraft towed instrument platform.

N01-140 TITLE: Conductive Carbon Nanotubes for EMI Shielding of Naval Aviation Optical Materials

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVAIR 4.1.8 Survivability

OBJECTIVE: Explore the feasibility of incorporating highly conductive carbon nanotubes in optical materials for Electromagnetic Interference (EMI) shielding. Optical materials such as aircraft canopies and infrared (IR) transparent windows have challenging combinations of electrical and optical requirements to meet Naval Aviation needs. Low loading of conductive fillers is required to have minimal impact to optical transmission through these materials.

DESCRIPTION: Recent advances in the fabrication of conductive carbon nanotube materials has imparted an opportunity to explore nano-molecular particles for EMI shielding for military as well as commercial applications. These materials have demonstrated good electrical conductivity in gap filler materials at low (3-5%) loading levels (Phase I SBIR with Foster-Miller). Furthermore, single walled carbon nanotubes have been demonstrated to increase the strength of polymers by forming strong chemical bonds to the matrix. Demonstrating good electrical conductivity with minimal visual transmission loss through aircraft canopy materials (e.g. polycarbonate) and IR transparent windows (e.g. sapphire, ZnS) would be innovative and provide a technology need for military weapon systems. The conductivity levels measured from a four point probe are of a threshold of 10 ohms per square and an objective of less than 1 ohm per square.

PHASE I: Establish the feasibility of incorporating conductive carbon nanotubes into aircraft canopy materials and IR transmitting materials. Measure optical transmission loss, mechanical strength impact, electrical conductivity, and any marine environmental exposure material degradation due to nanotube incorporation.

PHASE II: Identify EMI shielding optical requirements for specific subsystems components (canopies and IR missile domes) for Tactical Aircraft, Targeting Forward Looking IR (TFLIR), and IR Missile Domes. Fabricate coupons and subsystem components for test and evaluation of EMI effectiveness for aircraft canopies and IR windows.

PHASE III: Initiate production efforts to build and fabricate EMI shielding materials in commercial quantities. Prepare technology transition packages to specific Naval Aviation Program Offices (PMAs) for platform integration, production, and supportability. Prepare design documentation to produce suitable EMI shielding materials for these applications.

COMMERCIAL POTENTIAL: Application in several areas requiring EMI shielding such as commercial aircraft, ground stations, and cellular phones.

KEYWORDS: EMI shielding, optical materials, carbon nanotubes

N01-141 TITLE: Portable Emissivity / Reflectometer for Measurements on Curved Surfaces

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVAIR 4.1.8

OBJECTIVE: Develop a hand held emissivity measurement tool device to verify and quantify the infrared properties of installed materials such as paints and coatings on curved surfaces. The lightweight portable device should work on exterior surfaces with radii of 3 inches or greater and internal surfaces with radii of 12 inches or greater.

DESCRIPTION: Recent advances in Bi-directional Reflectometry (BRDF)measurement technology have shown the feasibility of conducting field emissivity measurements of flat surfaces coated with materials for enhanced reflective or emissive properties for improved durability performance. However, these hand held measurement tools require flat surfaces and are also difficult to handle due to high temperatures generated by the device during calibration. Many critical installations are made on singly and doubly curved surfaces and cannot be measured with this technology. This activity would conduct innovative research into the feasibility of accomplishing portable, lightweight, accurate, and calibrated BRDF measurements in the field without current constraints for nearly flat surfaces.

PHASE I: Conduct research into eliminating current limitations on curvature for conducting infrared measurements. Investigate alternative sensors and concepts to meet interior and exterior measurement needs with a single device. Establish the requirements for measurements in the naval environment.

PHASE II: Assess the needs for verification of infrared performance of the outer mould-line and engine cavities. Develop laboratory model of device using representative surface curvatures and coatings and design/build a prototype measurement device. Conduct field demonstration of prototype to verify its performance. Develop cost information and design specifications for a production measurement device.

PHASE III: Initiate production efforts to build the measurement device in commercial quantities. Prepare transition packages for specific platform organizational and depot support units.

COMMERCIAL POTENTIAL: A portable device for the measurement of infrared properties would have application in a commercial area such as industrial furnace maintenance and manufacturing where the durability of high temperature coatings is monitored. Monitoring is critical for process control such as uniformity of temperature.

KEYWORDS: Measurement, infrared, emissivity, reflectance

N01-142 TITLE: Rapid RF Switching Conducting Polymers

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVAIR 4.1.8 Survivability

OBJECTIVE: Explore the feasibility of developing rapid switching conducting polymers from low dielectric (opaque/RF transmissive) to high dielectric (conducting/RF reflective) materials for Electromagnetic Interference (EMI) shielding. Innovative rapid RF shuttering technology is need for multiple Naval Aviation antenna applications for EMI shielding.

DESCRIPTION: Recent advances in the fabrication of low cost conducting polymer materials has imparted an opportunity to explore these materials for EMI shielding of military antenna systems. Advance material research in conducting polymers is needed to provide affordable supportable solutions for RF shuttering to meet low one way transmission loss (<0.5 dB) from 2-18 GHz, rapid (<0.1 seconds) switch from conductive to opaque state, complex shape integration (flat to doubly curved surfaces), multiple cycle reliability (>10,000 cycles), low cost, and maintainability in a marine environment.

PHASE I: Establish the feasibility of incorporating conducting polymer switches for EMI shielding of antennas. Measure one-way RF transmission loss, mechanical strength, electrical conductivity, and any marine environmental exposure material degradation.

PHASE II: Establish EMI shielding optical requirements for specific subsystems components (antennas) for Tactical Aircraft, Rotary-Wing Aircraft, and weapon systems Fabricate coupons and subsystem components for evaluation.

PHASE III: Initiate production efforts to build and fabricate EMI shielding materials in commercial quantities. Prepare technology transition packages to specific Naval Aviation Program Offices (PMAs) for platform integration, production, and supportability. Prepare design documentation to produce suitable EMI shielding materials for these applications.

COMMERCIAL POTENTIAL: Application in several areas requiring EMI shielding such as commercial aircraft, anti-static carpets, computers, and cellular phones.

KEYWORDS: EMI shielding, RF shuttering, conducting polymers

N01-143 TITLE: Compact, Digital Man-Portable Infrared (IR) Measurement Device

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVAIR 4.1.8 Survivability

OBJECTIVE: Investigate the utility of and develop a hand-held IR measurement device to be used in an operational field/fleet environment to evaluate the IR signature characteristics of U. S. Naval aircraft and other military vehicles. The lightweight portable device should be usable and effective in adverse field conditions and simple to operate. Device should include software capability to compare reference datum and extract changes with sensitivities to less than 3 degrees F relative temperature, and changes in emissivity of less than 10 percent from reference datum at selective bands within the midwave infrared wavelengths and longwave wavelengths.

DESCRIPTION: As the U. S. Navy continues to design, develop and field advance coating technologies on military aircraft and UAVs, it is absolutely critical to the operational forces to ensure that the IR signature characteristics of the vehicle are not degraded in the harsh operational environments of aircraft carriers, ships in rough seas, and combat operations. As these systems are fielded, provisions are being made to evaluate and accurately measure their signatures in controlled environments with specific IR signature measuring equipment that will fully characterize the IR signature of the vehicle. These controlled measurements can only be conducted at depot or manufacturing plants where proper equipment and facilities are available.

This SBIR focuses on development of a small (less than one cubic foot volume for logistics footprint), lightweight (less than 8 pounds threshold and less than 5 pounds objective), digital IR camera that can be packaged as a man-portable measurement device to evaluate specific areas of a vehicle, to ensure that materials or durability coatings have not been degraded or damaged during operational use. The device will image the vehicle and provide a real-time IR image of the vehicle and associated scene background. The IR sensor must be capable of evaluating emissivity and/or thermal measurements and employ a suitable method of calibration and background/scene comparison to determine aircraft "hotspots" that are indicative of changes to the material properties on the vehicle surface, due to damage or materials degradation.

PHASE I: Conduct a feasibility study and requirements analysis that will result in the successful design and integration of various sensors/components needed to build a light-weight, digital, man-portable IR camera, with application as an evaluation tool for IR signature measurements and vehicle materials characteristics in an operational field environment. Define the range of operational performance and concept of operations for the device. Investigate alternative commercial off- the-shelf (COTS) sensors and concepts to meet measurement and evaluation needs with a single device. Establish the requirements for measurements in the naval environment.

PHASE II: Develop and build a working prototype of the IR measurement device. Demonstrate the ability of the device to identify "hot spots" on the vehicle and associated defects or material degradation that may have occurred. Assess the needs for verification of IR performance or calibration, based on baseline signature. Conduct a field demonstration of the prototype to verify measurement performance. Deliver a system specification to produce this device in Phase III. Develop cost information and design drawings suitable for device production.

PHASE III: Design and produce this digital IR measurement device in production quantities. Complete all support documentation for the device, including user's manual, maintenance/repair manuals, and an operations/evaluation guide

COMMERCIAL POTENTIAL: A portable device for the measurement of IR properties would have wide application in many commercial areas, such as police IR sensors, laboratory and industrial maintenance and manufacturing applications, where the durability of high temperature or durability coatings needs to be monitored and evaluated.

KEYWORDS: Measurement, infrared camera, emissivity

N01-144 TITLE: Small Diesel Engines, JP5 / JP8 Fueled

TECHNOLOGY AREAS: Air Platform, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMR-51

DESCRIPTION: Small model aircraft diesel engines are now commercially available as units and conversion components. These engines are designed to run on model aircraft diesel fuel, which is modified with high volatility ether for ease of starting. For use on Navy ships, small diesel engines would be required to operate on standard Navy heavy fuels, such as JP5 (MIL-DTL-5624) and JP8 (MIL-T-83133), with no volatile additives allowed. Development of highly efficient, small diesel engines (suitable for small UAVs) are needed to satisfy the standard Navy heavy fuel requirement. There are no engines currently available to meet this requirement

PHASE I: Demonstrate 24-hour operation using both JP5 and JP8 fuel (with no volatile additives) on a COTS, modified COTS, or prototype engine with 0.25 cubic inch displacement (cid). Demonstrate a specific fuel consumption (SFC) of less than 1.2 lbs/hp-hr (at sea level) while producing at least 1.4 hp/cid @ 11,000 rpm (at sea level) while maintaining a total engine weight (excluding propeller) of less than 10 oz and an estimated cost of less than $100 each in 100 lot quantities. Demonstrate a cold starting system that is portable, reliable, and inexpensive to produce. Estimate cost of production for 100 lot and 1000 lot purchases. Provide five samples of the prototype engine system.

PHASE II: Continue development of the 0.25 cid engine to demonstrate an SFC of less than 0.8 lbs/hp-hr (at sea level) and specific output of >1.8 hp/cid @ 11,000 rpm (at sea level) while increasing uninterrupted endurance to 48 hrs using both JP5 and JP8 fuels. Extend the design to an engine of approximately 2.0 cid with similar performance @ <6,000 rpm. Estimate cost of production for 100 lot and 1000 purchases for each size engine. Provide five samples of each size prototype engine system.

PHASE III: Prepare fabrication drawings and specifications of final designs for both size engines. Provide statistically valid performance and operational data including data for SFC, specific output, and uninterrupted endurance. Demonstrate engines in generic aircraft in various operational conditions, specifically winter operations. Refine cost estimates for 100 lot purchases. Provide twenty samples of each size engine system.

COMMERCIAL POTENTIAL: Small, efficient, diesel engines designed to operate on standard, turbine engine aviation fuels will have narrow application.

KEYWORDS: internal combustion; diesel; fuel; Specific Fuel Consumption (SFC); engine starting; JP5 / JP8

N01-145 TITLE: Very Low Cost, Lightweight Detector Technologies for Small, Expendable Unmanned Air Vehicles (UAVs)

TECHNOLOGY AREAS: Chemical/Bio Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMR-51

DESCRIPTION: A potential role for very low cost UAVs would be to provide either perimeter detection and alert or over-the-horizon intelligence to forces afloat, particularly during operations other than war. The detectors needed are primarily for the following classes (not necessarily simultaneously):

a) biological / chemical agents
b) nuclear radiation
c) explosives

Therefore, the U.S. Navy has a need for sensors capable of detecting, identifying, and then quantifying toxic, airborne chemical or biological agents, nuclear radiation, or explosives. These sensors should be compatible with deployment on small, expendable UAVs. Therefore, the sensor system should be lightweight (<4 pounds), small (<200 cubic inches), rugged, have low power consumption (<6 WDC), very low cost (<$1,000 each), and capable of autonomous operation. The sensor should be capable of simultaneously detecting several (>10) toxic agents at very low concentration (or level, as appropriate) with a low false alarm rate. The sensor system should be capable of assaying an air sample in near real-time (<60 seconds). The sensors should be capable of performing this near real time monitoring for a minimum period of 24 hours in a marine environment.

PHASE I: Examine potential sensor technologies for one or more of the above classes of threats. Evaluate two different technologies for applicability and build a lightweight breadboard prototype for demonstration. Measure the response levels and times for these sensor technologies using simulants or sources as appropriate. Assess potential costs for volume (1000 lot) production. Provide sample sensor system for government evaluation

PHASE II: Refine the technologies providing the best estimated combination of cost, weight and performance and demonstrate brassboard construction and delivery of 3 functional units for test and evaluation. Measure the response levels and times for these sensor technologies using real agents or sources as appropriate. Estimate final production costs for 1000 lot production.

PHASE III: Complete brassboard design and demonstrate production capability with the construction and delivery of 25 functional units from prototype construction. Measure the response levels and times using this sensor system in a UAV using real agents or sources as appropriate. Refine final production costs for 1000 lot production.

COMMERCIAL POTENTIAL: The demonstration of very low cost sensor technology will enhance the capability to incorporate a vast array of new sensors into both consumer and industrial goods.

KEYWORDS: sensor, chemical, biological, explosive detector, electronic nose, UAV, very low cost

N01-146 TITLE: Airframe Construction for Small, Expendable Unmanned Air Vehicles (UAVs)

TECHNOLOGY AREAS: Air Platform, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMR-51

DESCRIPTION: Most current UAVs are manufactured in a manner similar to prototype aircraft. While these techniques result in vehicles that are dimensionally accurate and aerodynamically capable, the costs are substantial. If an expendable UAV is to be adopted for general use, its construction cost needs to be low. Therefore, a significant emphasis must be placed on the fabrication of the airframe using inherently low cost processes, while maintaining the required aerodynamic and dimensional tolerances. There are a number of novel polymer fabrication technologies that may provide suitable performance but have never been evaluated for this large a component or have never been developed to maintain the exacting dimensional characteristics that would be required for an aerodynamic application (3D accuracy and surface finish).

PHASE I: Examine potential non-metallic fabrication technologies. Fabricate 4' prototypes using three to four of the suggested technologies and assess their performance, both structurally (static and dynamic) and aerodynamically as a function of weight. Goals for this phase would be a hardbody (wing, fuselage) and control surfaces weighing less than 2.6 lbs while capable of withstanding 10g acceleration (5 seconds) due to downdrafts for a completed vehicle weight of 20 lbs. Furthermore, the exterior dimensional goals should be 0.050" (in all three axes) and a surface finish and waviness of less than 8 microinches rms. Statistically measure and document the progress toward meeting these goals. Age six complete samples at elevated temperature (140F) for 24 hours, remeasure dimensional tolerances and report.

PHASE II: Select the two technologies assessed to provide the best combination of cost and performance and demonstrate low volume production (using prototype tooling and quality control) of selected airframes with the construction and delivery of 10 units using each technology. Goals for this phase would be a hardbody (wing, fuselage) and control surfaces weighing less than 2.0 lbs while capable of withstanding 10g acceleration (5 seconds) due to downdrafts for a completed vehicle weight of 20 lbs. Furthermore, the exterior dimensional goals should be 0.025" (in all three axes) and a surface finish and waviness of less than 8 microinches rms. Statistically measure and document the progress toward meeting these goals. Age six complete samples at elevated temperature (140F) for 48 hours, remeasure dimensional tolerances and report.

PHASE III: Select the final technology providing the best combination of cost and performance and demonstrate volume production (using production tooling and quality control) of selected airframes with the construction and delivery of 40 units. Statistically measure and document the final weight and dimensionally accuracy of the delivered units. Age six complete samples at elevated temperature (140F) for 96 hours, remeasure dimensional tolerances and report.

COMMERCIAL POTENTIAL: The demonstration of very low cost, highly accurate non-metallic fabrication technology will permit designers to conceptualize a vast variety of large, low cost precision items for both the consumer and industrial markets.

KEYWORDS: precision manufacturing, UAV, low cost, non-metallic, fabrication, small airframe

N01-147 TITLE: Very Low Cost Unmanned Air Vehicle (UAV) Avionics

TECHNOLOGY AREAS: Air Platform, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMR-51

DESCRIPTION: For a well-developed small Expendable UAV, the predicted cost of the airframe and power plant are very low – in the order of several hundreds of dollars. The cost drivers for these systems are both the communications and avionics subsystems. This effort addresses the avionics portion where costing progress must be made. A very low cost, lightweight (~6 oz), low power (<3 WDC), high-update rate avionics module is needed for supporting airframes ranging from 2 to 12 foot wingspan. This module should provide real-time GPS, independent inertial guidance, the storage of hundreds of geographic waypoints, the adaptive capacity to cross waypoints at designated times, and allow the input from off-board sensors to be used to alter its flight plan. It must operate in a high EMI environment, use minimal power, and remain reliable for >100 hours while operating in a very high vibration environment.

PHASE I: Design a breadboard avionics system (including all servos) that will be inexpensive to produce and demonstrate system performance using generic control laws. The cost target should be approximately $400, or about 30% of commercial systems that are currently available. Preliminary packaging concepts are to be explored and he sensitivity of the system to extremely broadband EMI is to be measured. The operation of the system under realistic GPS spoofing situations is to be evaluated and the ability to switch to inertial guidance will be demonstrated. A complete prototype of the avionics system is to be provided to the government for test and evaluation.

PHASE II: Demonstrate potential producibility and operation of prototype system. Verify performance and reliability of brassboard systems in prototype air vehicles in a high EMI environments and under simulated GPS spoofing conditions. Demonstrate operation in a wide array of temperature/humidity environments in the laboratory. Provide 5 complete avionics systems for government test and evaluation

PHASE III: Complete designs suitable for high-rate fabrication. Develop production and test systems to statistically ensure reliable operation of 99% of delivered units. Provide 10 complete avionics systems for test and evaluation.

COMMERCIAL POTENTIAL: The cost target of this system will put it into a cost area that is viable for model airplane enthusiasts.

KEYWORDS: avionics; low-cost; UAV; GPS; electronics; production

N01-148 TITLE: Very Low Cost, Lightweight IridiumTM / GlobalstarTM Communications Modules

TECHNOLOGY AREAS: Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMR-51

DESCRIPTION: With the recent decision by the US Government to become the dominant user of the IridiumTM satellite system, there could be a very significant capability for using either it or the GlobalstarTM system to permit near real-time, two-way communication and control of UAVs. What is required is both the hardware and the software that can provide this data communications capacity over these systems using very low cost components at the vehicle level. The onboard system should be capable of providing some form of non-exploitable, short-term (500 hr) secure encryption for transmission at data rates up to 10 K bytes / sec. The power requirement should be <3WDC, the complete system should weigh <8 oz, and the system should be reliable for >48 hours in a very high vibration environment.

PHASE I: Develop a proof of concept, breadboard, very low cost datalink system using either commercial SATCOM system. Demonstrate required data rates in the lab and examine worst case data rates that would be expected in the field. Include support documentation explaining how final flyaway cost will meet or exceed cost/weight/size/performance objectives. Provide 2 vehicle level systems for test and evaluation.

PHASE II: Design vehicle size prototype and demonstrate a 10K bytes/ sec data link between an airborne vehicle in a high EMI environment and a ground system stationed at >200nm. Develop brassboard system units and evaluate them in prototype vehicles. Provide 6 functional vehicle level units for test and evaluation. Estimate cost of production for 1000 lot size.

PHASE III: Demonstrate production capability with the construction and delivery of 25 functional units. Test 10 additional units airborne in an appropriate UAVs for uninterrupted periods >24 hours. Report their performance and project their reliability. Estimate final cost of production in lots of 1000.

COMMERCIAL POTENTIAL: The demonstration of very low cost sensor technology will enhance the capability to incorporate a vast array of new sensors into both consumer and industrial goods.

KEYWORDS: commercial SATCOM, UAV, very low cost, lightweight, datalink

N01-149 TITLE: Expendable Active Battle Damage Assessment Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NSWC Dahlgren

OBJECTIVE: Develop and demonstrate a small low cost expendable active sensor that can detect and transmit battle damage information following strikes by special technology payloads.

DESCRIPTION: When special technology payloads are used, verification and / or Battle Damage Indications (BDI) can be difficult to obtain. Normally, BDI is based on observing target status before and after a strike. For non-explosive payloads, however, another form of BDI must be employed to assess payload effectiveness. Such a sensor must detect target responses in one or more electro-optical bands including infrared (IR), radio frequency (RF), and / or acoustic responses from the target or target area. Target responses must then be transmitted via tactical (satellite) data-links back to the on-scene commander using a scheduled time interval for up to 2 hours. The sensor used must have a maintenance cycle of at least 15 years and be capable of activation upon deployment without any electrical signal (autonomously). The sensor must be capable of surviving deployment from an airborne platform at an altitude of 1000 feet at airspeeds up to 500 knots.

PHASE I: Define requirements for active sensors based on electro-optical band of interest. Identify potential sensors, data links, and power supplies. Design a ballistic retardation and an activation device. .

PHASE II: Integrate components into a cylindrical shape no larger than 6 ½ inches long by 2 ½ inches in diameter including the container. Conduct a static demonstration to verify the sensors ability to detect target changes. Conduct dynamic testing to verify the sensor's ability to withstand dispense / impact and to provide real time data on target status via a data link.

PHASE III: Conduct cost and risk reduction analyses and demonstrate producability of the BDA sensor/dat link package. Develop a production and implementation plan for integrating a few packages into each Tomahawk land Attck Missile during the standard TLAM maintenance cycle.

COMMERCIAL POTENTIAL: This sensor could be adapted as a low cost alternative for locating downed aircraft in remote areas.

KEYWORDS: Battle Damage Indicators, Battle Damage Assessment, sensors, satellite data link

Naval Supply Systems Command (NAVSUP)

N01-150 TITLE: Technology for Logistics Productivity

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: A component is determined to be obsolete when its commercial availability becomes limited or nonexistent. The government spends millions of dollars to emulate replacement parts, redesign systems and equipment, find alternative sources or invest in life of type buys. The objective of this topic is to identify, develop and demonstrate the replacement or upgrade of a Navy system, subsystem or equipment suffering from obsolescence. It may be an electronic, mechanical or electro-mechanical system, subsystem or equipment. The technology demonstration must also provide a clear cost avoidance over the current system or equipment's replacement/upgrade strategies and significantly contribute to total ownership cost reduction.

DESCRIPTION: Because of rapid changes in technology, functional and economic obsolescence are both significant contributors to the high life cycle costs of Navy systems. The Naval Supply Systems Command (NAVSUP), under the sponsorship of the Office of the Chief of Naval Operations (OPNAV), manages the Navy Logistics Productivity Program, which is focused on increasing the life cycle of Navy systems through technology insertion. The current efforts, two of which are funded through Phase III SBIR contracts, address electronic systems obsolescence. However, not all of the electronic spectrum is addressed and there are no initiatives that address mechanical or electro-mechanical systems. In addition to specific technological submissions for electronic, mechanical or electro-mechanical systems, NAVSUP is also looking for tools that will help reduce costs associated with the technology insertion program. Examples of these tools might include, but are not limited to, smart scanners, raster to vector conversion tools, and automatic code generators.

PHASE I: Develop an overall design, to include a technical specification that demonstrates feasibility.

PHASE II: Develop and demonstrate a prototype in a realistic environment. Conduct testing to provide feasibility over extended operating conditions.

PHASE III: Develop and deliver a final application of the technology for commercial and military use.

COMMERCIAL POTENTIAL: The product could be used in a broad range of military and civilian applications where obsolescence is a significant detractor. An example of dual use applicability could be components utilized in both military and commercial aviation.

REFERENCES:

1. Navy Logistics Research & Development Program, Gary Fitzhugh, Richard Comfort and James Fitzgibbon, availabale at http://www.nlc2000.org/papers/Fitzhugh.pdf
2. Government Initiatives to Solve Diminishing Manufacturing Sources/Material Shortages (DMSMS), available at http://www.gidep.corona.navy.mil/dmsms/dmsinfo.htm

KEYWORDS: Obsolescence; Electronics; Mechanical; Electro-Mechanical; Tools; Code; Scanner

N01-151 TITLE: Laboratory Convective / Steam Heat Test Apparatus

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: NCTRF (Navy Clothing & Textile Research)

OBJECTIVE: Develop and demonstrate a test apparatus to measure the amount of heat that would pass through a fabric sample or composite when subjected to high levels of convective heat and steam. The apparatus should also be able to measure the temperature rise between layers of composite materials.

DESCRIPTION: Currently the Navy has no way of evaluating materials for their ability to protect against both convective heat and steam. Navy personnel have experienced burns during fire fighting due to the combined effects of convective heat and steam. Because there is no way to evaluate materials for their ability to protect under these conditions, to insure protection, Navy currently offers maximum protection at a high cost. With this test apparatus, the Navy will be able to evaluate numerous types of fire-protective materials at a reduced cost. For example, the Navy submarine force has a protective ensemble to protect against steam leaks. However, there is no way to evaluate new material composites to upgrade the suit unless suits are manufactured from numerous material combinations and subjected to high cost testing at the full scale steam facility. The apparatus shall have the following parameters:
- Temperature Range - Up to 1000 degrees F.
- Steam Condition - 0 PSI at 212 °F. (on face of material)
- Recording Device - The recording device shall have the capabilities of listing all temperatures / pressures every half second of apparatus use. Must also be capable of plotting the time temperature relationships of the sample.

PHASE I: Develop an overall design of the testing apparatus, to include materials, cost data and engineering drawings.

PHASE II: Construct prototype apparatus and demonstrate performance by testing 50 samples (to be furnished by the Navy Clothing and Textile Research Facility).

PHASE III: Develop and deliver a final testing apparatus for use by civilian and military testing laboratories.

COMMERCIAL POTENTIAL: The apparatus will become a standard means of evaluating material composites as they relate to the protection of personnel from heat and steam. The procedure would become a standard test for evaluation of protection for fire fighters and others subjected to this type of environment. Manufacturers and laboratories that work in these areas would procure the instrument. This device would reduce research costs and allow the procurement of cost-effective protective clothing with confidence that it will perform as anticipated. The reduced testing cost will benefit both military and civilian users.

REFERENCES:

1. National Fire Protection Standards NFPA 1971, 1976, 1991, and 1992.

KEYWORDS: Fire Fighting; Convective Heat; Steam; Protective Materials; Testing; Testing Apparatus

N01-152 TITLE: Environmentally Friendly Advanced Food Packaging

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: NAVICP Code 077

OBJECTIVE: Develop and demonstrate biodegradable packaging films for Navy food services that degrade in the marine environment and function according to current food wrap performance specifications.

DESCRIPTION: The Marine Pollution Treaty does not allow plastics to be thrown overboard ships. Current food packaging contributes to plastic waste Navy ships generate, store and must ultimately dispose. The replacement of plastic material used to package food with biodegradable packaging materials will significantly reduce the burden of food packaging disposal. The Navy is most interested in meat and vegetable wrappings with barrier properties for oxygen and water vapor permeability. Wraps are needed that are strong and protect foods from moisture loss. Protection of precooked, preserved, frozen, or fresh foods, including meats, grains, vegetables, or beverages, will be considered during evaluation. The new packaging material should be marine biodegradable, non-pollutant, and non-toxic for food applications. Water solubility, film formability, viscosity, moldability, and biodegradability of the packaging product will be considered. The wrap will be a desirable alternative to traditional plastic wraps for food with properties that include odorless, toughness, strength, gas impermeable (oxygen), heat sealable, and machine processable.

PHASE I: Develop a marine biodegradable food packaging item to meet the performance specifications for military use. The material, product design and manufacturing process all need to be considered.

PHASE: Demonstrate an optimum material and processing method, with a sample passing storage studies and performance tests.

PHASE III: Produce and market new product.

COMMERCIAL POTENTIAL: These products will be directly used by the Navy and other military services, and can be transitioned to the commercial sector where food packaging items are utilized (e.g., fast food establishments, school cafeterias, restaurants).

REFERENCES:
1. Biodegradable Polymers and Packaging, Ching, C., Kaplan, D., Thomas, E., Technomic Publishing Co., Inc., Lancaster, PA, 1993.
2. Simulated Marine Respirometry of Biodegradable Polymers, A. Allen, J. Mayer, R. Stote, D. Kaplan, Journal of Environmental Polymer Degradation, Vol. 2, No. 4, 1994.
3. Polymers From Renewable Resources, R. Gross, C. Scholz, American Chemical Society Symposium Series, December 2000.

KEYWORDS: Biodegradable; Marine Environment; Packaging; Food; Barrier; Wrap

Naval Air Systems Command (NAVAIR)

N01-153 TITLE: Low Volatile Organic Content (VOC) Solid Film Lubricant

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO, Air, ASW, Assault & Special Mission

OBJECTIVE: Develop a low VOC content solid film lubricant, which contains no lead or antimony and meets the performance requirements of MIL-L-23398 and/or MIL-L-46147.

DESCRIPTION: Solid film lubricants are used in a variety of applications. For example, they aid in the assembly and subsequent disassembly of mated parts (such as threaded fasteners, turbine discs, and blade roots), and in the prevention of galling and fretting of aircraft engine parts. Recently, a solid film lubricant has been developed that contains no lead or antimony but it does not meet the endurance life requirement in the MIL-L-23398 specification. Furthermore, it contains high levels of VOCs. These VOCs promote the application of the lubricant but their emissions contribute to environmental air pollution.

PHASE I: Develop a low VOC content solid film lubricant that meets the performance requirements of MIL-L-23398 and/or MIL-L-46147. Assess the impact of the organic compounds on surface contact and adhesion of a lubricant. Address the practicality and feasibility of reformulating the solid film lubricant. Select organic compound(s) for a Phase II reformulation of a low VOC lubricant

PHASE II: Conduct laboratory tests of varying concentrations of the low VOC compound(s) on the wear, corrosion, and galling of a solid film lubricant. Identify the concentration of the low VOC compound(s) that give the best performance. Reformulate the lubricant and conduct performance evaluation using the requirements of MIL-L-23398 and/or MIL-L-46147. Assess the effect of this low VOC solid film lubricant on the Navy's overall VOC emissions. Refine lubricant production processes.

PHASE III: Conduct full-scale demonstration.

COMMERCIAL POTENTIAL: Low VOC solid film lubricants have direct replacement to current solid film lubricants use in military and commercial markets to prevent wear, galling and fretting, and to assist in assembly and disassembly of parts.

REFERENCES:
1. MIL-L-23398, Lubricant, Solid Film, Air-Cured, Corrosion Inhibiting, NATO Code Number – 749
2. MIL-L-46147, Lubricant, Solid Film, Air Cured (Corrosion Inhibiting)

KEYWORDS: Environmentally Friendly; Solid Film Lubricant; Dry Film Lubricant; Air-Cured; Corrosion Protection; Volatile Organic Compound

N01-154 TITLE: Probabilistic Mission/Engine Duty Cycle Analysis

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO, Tactical Aircraft Programs

OBJECTIVE: Develop an analytical method and tool to generate both a deterministic and probabilistic mission mix in order to evaluate flight mission data and engine duty cycles for low and high cycle fatigue drivers.

DESCRIPTION: Mission analysis data is essential in determining low and high cycle fatigue life prediction for engine components. Currently, a single mission profile is used to represent all variations for a particular mission type. This deterministic profile is based on an average mission and does not accurately reflect all of the critical operational conditions. A probabilistic mission/engine duty cycle analysis program will address this deficiency by statistically modeling required parameters (i.e., power level angle, altitude, airspeed, rotor speeds, turbine temperatures, after burner lights, and variable guide vane angles) and translate mission profiles into a statistical representation. This representation will be used to increase the fidelity of the life assessment process. Developing this analytical method/tool will provide an accurate representation of how specific aircraft are used. The probabilistic mission/engine duty cycle analysis will reduce the engineer's workload, increase responsiveness to customer(s), and produce a high quality analysis in consistent fashion across all military platforms.

PHASE I: Develop technologies and software that provide deterministic and probabilistic analysis programs. The software must be able to accept various input formats, provide deterministic and probabilistic/statistical analysis tools, display data/results in graphical form, and output results in both soft and hard formats.

PHASE II: Expand the development, test and demonstration of the software program by analyzing actual field data and identify an average mission mix and engine duty cycle based on a deterministic approach. The contractor will provide operational software, source code, documentation, and user manuals.

PHASE III: Transition the analysis to generate a probabilistic mission mix and engine duty cycle. The contractor will provide final operational software, source code, documentation, user manuals, and if necessary, on-site training.

COMMERCIAL POTENTIAL: This software program could be used by commercial airlines to monitor/develop their engine/aircraft usage.

REFERENCES:
1. Functional Specification, Automated Engine Cycle Analysis, 10 March 1992

KEYWORDS: High Cycle Fatigue; Low Cycle Fatigue; Probabilistic; Engine Duty Cycle; Mission Analysis; Engine Flight Parameters

N01-155 TITLE: Coupled Vertical/Short Takeoff and Landing (VSTOL) Down Wash-Ground Effect and Ship Air Wake Turbulent Flow Simulation Model

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0 (Program Management for Acquisition and Operations)

OBJECTIVE: Develop a modeling tool based on computational fluid dynamics (CFD) to simulate the interaction of VSTOL flow and the unsteady air wake produced by the super structure of the ship for the purpose of predicting and enhancing VSTOL aircraft dynamic interface (DI) performance

DESCRIPTION: VSTOL aircraft such as the JSF and AV-8B encounter unique challenges during shipboard (DI) operations (takeoff and landing) due to the interaction of the propulsion-generated down wash and the unsteady air wake generated by the ship. Operating envelopes, also known as wind-over-deck (WOD) envelopes, are currently developed through at-sea trials. These trials are quite costly because they require the dedicated use of a ship, aircraft, and the personnel to support the test. In addition, the WOD envelopes that result from such tests may be overly restrictive if the wind conditions are too mild during the test period. Safety is also an issue during these trials since the aircraft have not been flown in the trial wind conditions before. An innovative approach is sought to model the coupled airflow of a ship/VSTOL-aircraft combination to predict DI performance. The general approach should use time-accurate CFD to predict the overall flow field. The tool should be flexible enough to model a complete 360° azimuth of wind conditions at wind speeds from 15 to 30 knots. Results should include predictions of DI performance (for example pilot workload). The tool must be validated at each stage of development. The anticipated validation process includes the following elements: validation of VSTOL aircraft in ground effect predictions; validation of ship air wake predictions; validation of coupled VSTOL/ship flow field predictions; and validation of WOD envelope predictions. Validation efforts may use both wind tunnel and flight data.

PHASE I: Develop and validate the initial CFD tools to predict the VSTOL-in-ground-effect flow field and the ship air wake flow field. Develop the conceptual approach to model the coupled flow field and WOD predictions.

PHASE II: Develop the tools and approach to model the coupled flow. Develop the tools to generate the WOD operating envelopes. Validate the tools for one VSTOL-aircraft/ship combination

PHASE III: Upon validation of the tools for one aircraft/ship combination, the tools/process can be transitioned to industry and government to predict and enhance DI performance for current and future VSTOL aircraft.

COMMERICAL POTENTIAL: The modeling tools developed to simulate aircraft ground effects could be used for commercial helicopters such as those used by the Coast Guard, police, and medical evacuation helicopters in order to enhance DI performance. The result would be improved safety by identifying possible hazardous areas before the aircraft will encounter them in real life and by improving pilot training through enhanced real-time simulation. The tools developed could also be used to aid in the design of commercial Vertical VSTOL aircraft.

REFERENCES:

1. "Time Accurate Computational Simulations of Ship Air Wake," AIAA paper 2000-4126 2. Joint Ship Helicopter Integration Process (JSHIP) program documentation

KEYWORDS: Vertical/Short Takeoff and Landing (VSTOL); Computational Fluid Dynamics (CFD); Air Wake; Dynamic Interference (DI); Ground Effect; Wind Over Deck

N01-156 TITLE: Nonlinear Combustion Stability Prediction of Solid Rocket Motors

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PEO-T, Tactical Aircraft Programs

OBJECTIVE: Develop and validate a computational design tool that will predict the combustion stability characteristics of realistic full-scale solid propellant rocket motors. The code should account for variations in three-dimensional grain designs, ballistic parameters, and propellant formulations. The new code should be able to predict linear as well as nonlinear combustion instability behavior, including limiting oscillatory amplitudes, triggering levels to cause instabilities, nonlinear particle damping, and three-dimensional mixed acoustic mode analysis.

DESCRIPTION: The Navy, Air Force, Army, and to some extent NASA, currently depend upon the Air Force funded Solid Propellant Rocket Motor Performance Computer Program (SPP) to evaluate the acoustic stability of solid rocket motors

(reference 1). The SPP stability prediction model is limited to linear stability analysis. Recently, numerous development rocket motors have experienced stability concerns that are outside the predictive capability of the current stability code. It is proposed to increase the capability of the design code to include various nonlinear predictive capabilities coupled to axi-symmetric, 2-D and three-dimensional grain design and ballistics. Nonlinear behaviors include limiting oscillation amplitude, pulsing thresholds, metal distributed combustion, nonlinear particle damping, nonlinear response and mixed acoustic mode analysis. All of this will be performed using a time dependent three-dimensional internal ballistic model. The ballistic model will include both three-dimensional grain design and three-dimensional acoustic fields. The stability model will have the capability to predict the nonlinear acoustic stability of both longitudinal and tangential acoustic modes. The code to be developed will be a practical industrial engineering tool for motor design as opposed to a research tool more suited for a university environment.

PHASE I: Perform a feasibility study to determine the physical models for inclusion into the code to predict nonlinear solid rocket stability. One potential source for physical models is from a recent effort funded by the Office of Naval Research (ONR) and the Ballistic Missile Defense Organization (BMDO) which developed three distinct methodologies to predict non-linear stability (references 2-6). The approach chosen in Phase I should consider not only the physical models, but also the suitability for inclusion in a three-dimensional motor stability analysis combined with full up ballistic prediction.

PHASE II: Implement the nonlinear analyses selected in Phase I into a usable computational engineering tool. Items for inclusion should include nonlinear response, limiting amplitudes, pulsing thresholds, distributed metal combustion, two phase flow, nonlinear particle damping, mixed mode acoustic analysis, complicated flow field effects. Include traditional linear stability prediction.

PHASE III: Refine the code for commercial use, including operational manuals, test cases, and graphical interfaces and provide a variety of versions for different computer platforms.

COMMERCIAL POTENTIAL: The program will have widespread use throughout the solid rocket motor community for both research and development and will be used in industry, government and university environments. Solid rocket motors of all sizes and applications will benefit from this work including intercontinental ballistic missiles (ICBMs), tactical systems, ground based defense systems and space motors. Prime defense contractors, solid rocket contractors, intelligence agencies and sub-contractors will be interested in licensing the software. The technology can also be extended to other combustion devices such as turbine engines for both military and commercial applications.

REFERENCES:
1. "A Computer Program for the Prediction of Solid Propellant Rocket Motor Performance (SPP), Vol. VI, Standard Stability Prediction Program for Solid Rocket Motors (SSP)," G. R. Nickerson, F. E. C. Culick, and L. D. Dang, Air Force Rocket Propulsion Laboratory, Edwards Air Force Base, California, AFRPL-TR-83-017, September 1983.
2. "Nonlinear Combustion Instabilities and Stochastic Sources" V.S. Burnley, Ph'D Thesis, California Institute of Technology, Pasadena, CA, 1996.
3. "Some Influences Of Nonlinear Energy Transfer Between The Mean Flow And Fluctuations," F.E.C. Culick, G.C. Isella, California Institute of Technology, Proceedings of the JANNAF Combustion Meeting, CPIA-PUB-662-Vol-II, Oct 97.
4. "Nonlinear Unsteady Combustion Of A Solid Propellant," G.A. Flandro, University of Tennessee, Proceedings of the JANNAF Combustion Meeting, CPIA-PUB-662-Vol-II, Oct 97.
5. "Two-Phase Turbulent Flow Interactions In A Simulated Rocket Motor With Acoustic Waves, W. Cai and V. Yang, Pennsylvania State University, Proceedings of the JANNAF Combustion Meeting, CPIA-PUB-662-Vol-II, Oct 97.
6. "Some Influences of Noise on Combustion Instabilities and Combustor Dynamics," F.E.C. Culick and C. Seywert, 36th JANNAF Combustion Meeting, Cocoa Beach, Florida, Oct 99.

KEYWORDS: Combustion Stability; Solid Rockets; Grain Design; Ballistics; Performance Prediction; Nonlinear Acoustics

N01-157 TITLE: Transparent, Electrically Conductive Coatings for Infrared Windows

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO(T), Tactical Aircraft Programs

OBJECTIVE: Develop durable, infrared-transparent, electrically conductive coatings for windows and domes of forward looking infrared (FLIR) sensors, infrared search and track (IRST) sensors, and infrared seekers.

DESCRIPTION: Infrared sensors are adversely affected by stray radio frequency and microwave radiation. Electromagnetic interference (EMI) can generate spurious signals or high levels of noise in the infrared detector. Therefore, EMI shielding is desired or required on sensor windows. Metallic meshes for EMI shielding significantly degrade the optical signal passing through the window and tend to be easily eroded by high-speed impacts of rain and sand. A durable, continuous, electrically

conductive, infrared-transparent film would be an ideal substitute for a metallic mesh. A conductive coating, that allows electromagnetic blending of the sensor compartment with the rest of the airframe, can help to reduce overall electromagnetic signature. A continuous coating will reduce total ownership cost of an infrared window because the coating should be less expensive than a metallic mesh and last longer.

Existing conductive, visibly transparent materials, such as indium tin oxide, are not sufficiently transparent in the infrared region. P-type semiconductors, such as copper aluminum oxide, offer the possibility of being transparent at infrared wavelengths and have adequate conductivity for electromagnetic shielding. To reject 99 to 99.9 percent of radio frequency energy, a thin conductive coating should have a sheet resistance of < or = 10 ohms/square. The conductive layer should be part of an antireflection coating that achieves an overall mean transmittance of > or = 80 percent at visible wavelengths, 1–1.5 μm, and 3–5 μm for a sapphire or multi-spectral zinc sulfide window.

PHASE I: Identify candidate coating materials that are electrically conductive and provide infrared transparency at 3–5 (or 8–10) μm wavelengths. Deposit thin films of candidate materials on a nonconductive substrate such as glass and measure the electrical sheet resistance or radio frequency reflection. Deposit thin films on inexpensive, infrared-transparent substrates such as silicon and measure the infrared transmittance. Identify coating material(s) for Phase II development. Assess the feasibility, practicality and technical risk associated with depositing a coating on infrared sensor windows. Goals are a sheet resistance of < or = 10 ohms/square and a mean transmittance of > or = 80 percent at visible wavelength, at 1–1.5 μm and at 3-5 or 8-10 μm.

PHASE II: Optimize material composition for high electrical conductivity, high infrared transparency, and good adhesion. Demonstrate deposition on sapphire (for 3-5 μm transparency) or zinc sulfide (for 8-10 μm transparency) substrates. Measure the conductivity and transmission of coated substrates. Evaluate coated substrates stability with respect to temperature excursions and exposure to sunlight. Determine rain and sand erosion resistance of coated disks. Incorporate the conductive layer into an antireflection coating. Identify final coating and coating deposition development requirements for Phase III.

PHASE III: Finalize coating deposition process. Deposit coatings on flat surfaces and hemispheres up to 200 mm in diameter. Demonstrate transparency and electrical conductivity. Conduct full-scale evaluation using an infrared sensor. (Note: the infrared sensor will be identified during Phase III.)

COMMERCIAL POTENTIAL: Transparent, conductive coatings are used in flat panel displays and in photovoltaic cells to convert sunlight into electricity. The combination of p- and n-type transparent semiconductors offers a unique opportunity for generating ultraviolet radiation from a hetero-junction diode at room temperature [2].

REFERENCES:
1. H. Kawazoe, M. Yasukawa, H. Hyodo, M. Kurita, H. Yanagi and H. Hosono, "p-Type Electrical Conduction in Transparent Thin Films of CuAlO2," Nature, 389, 939-942 (1997).
2. H. Kawazoe, H. Yanagi, K. Ueda and H. Hosono, "Transparent p-Type Conducting Oxides: Design and Fabrication of p-n Heterojunctions," Mater. Res. Soc. Bull. 25, 28-36 (2000)
3. D. C. Harris, Materials for Infrared Windows and Domes, SPIE Press, Bellingham, Washington, 1999, pp. 207-210.

KEYWORDS: Conductive Coating; Infrared Window; FLIR Window; Electro-Optic Sensor; EMI Shielding; P-Type Semiconductors

N01-158 TITLE: <u>Enhanced Propeller Visibility</u>

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-T, Tactical Aircraft Programs

OBJECTIVE: Develop a method for insuring all light condition visibility/awareness of aircraft propellers to insure aircrew safety.

DESCRIPTION: The E-2C and C-2A are the only remaining two propeller driven aircraft deployed on U.S. Navy aircraft carriers. High tempo 24 hour day and night flight operations demand that good safety procedures be adhered to and followed by all aircraft carrier personnel. The E-2C program desires to enhance carrier personnel safety by providing innovative aids that increase personnel awareness of rotating propellers/rotors at night and in low visibility conditions. The goal is to reduce the risk of carrier personnel being inadvertently struck by rotating propellers or rotors. The aids should make use of but are not limited to advanced computer hardware and software, lightning, paint and sound technologies. The approach may be one or a combination of technologies. The approach should consider keeping weight and power requirements to a minimum and satisfy the carrier E3

environment requirements if applicable. The approach should be easily incorporated on ship, aircraft or personnel as required. The goal is to implement this technology into carrier flight operations/procedures in two years or less.

PHASE I: Provide a design concept, including theoretical performance specifications in all weather/light conditions, which would be prototyped and demonstrated during Phase II.

PHASE II: Finalize the design and fabricate a functional prototype that may be demonstrated on a selected propeller driven aircraft. Performance tests addressing the specifications reported in Phase I should be conducted.

PHASE III: Improve functional prototype demonstrated in Phase II to a reliable airworthy maintainable component and/or system. Ensure that the technology produced during Phase II can be effectively produced and incorporated efficiently into propeller driven aircraft and helicopters.

COMMERCIAL POTENTIAL: Aircraft manufacturers (both civilian and military aircraft) would incorporate this technology to provide additional safety for ground and air crews required to work in close proximity of propeller aircraft. Commercial airlines flying commuter aircraft and helicopter operators would incorporate this technology to reduce the risk of propeller/rotor strikes and improve safety.

KEYWORDS: Propeller; Visibility; Rotors; Safety; Sensors; Software

N01-159 TITLE: Material Encoded Textures with Computer Generated Forces (CGF)

TECHNOLOGY AREAS: Information Systems, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0, (Program Management for Acquisition and Operations)

OBJECTIVE: Using the newer high-end geo-specific scene rendering technologies develop a Computer Generated Forces/Semi-Automated Forces (SAF) System that is not constrained by current polygon/vector based methods.

DESCRIPTION: Currently, the largest cost issue facing training system developers is creating highly correlated descriptions of the training environments in several different formats in parallel to support several different networked simulators and multiple sensors within a simulator. New technologies are emerging that hold promise in providing more realistic simulation by increasing correlation between the human training systems and the computer-generated forces at a reduced cost.
An example would be pixel-level material encoded textures. For multiple sensor scene generation within a human-in-the-loop-training simulator, the issue of multiple formats/versions of the database is addressed thru the use of an Open Commercial format (Terra-page) that supports the Navy developed concept of pixel level material encoded textures. The pixel level material encoded textures allows positional and spatial correlation for simulations of out-the-window (OTW), forward looking infrared (FLIR), night vision devices (NVD), synthetic aperture radar (SAR), and mission function (MF) through the use of interrupting the sensor response of the material(s) encoded at each pixel from a common copy of the database.
However, the SAF systems used by all the services do not use textures. Currently, polygons/vectors representations determine the environment impact on the computer generated entity, such as mobility, route finding, etc. Because polygons are several magnitudes larger than the pixels, they inhibit the SAF system correlation with pixel level based human systems and thus cannot provide a "Fair Fight" scenario. By applying the new knowledge such as pixel level material encoded textures into an existing SAF framework it would increase its correlation with human systems and decrease associated program costs. Assuring correlation (both location and spatial) through the use of the exact same data, reduces production costs and shortens development schedule by removing redundant efforts in data transformation by using the exact same description of the environment.

PHASE I: Assess the current polygon/vector based SAF system database structures and architecture to determine the ability of a system to be modified to integrate/interface the new technologies. Identify system functions that will require modification or development. Define a hardware and software design concept for development in Phase II. Technologies to be applied/developed would leave intact the legacy system's cognitive and behavior modeling system.

PHASE II: Develop the architecture, algorithms, and hardware for system operation. Assemble and install a prototype system by modifying an existing SAF system. Demonstrate proper operation of the SAF to include, mobility, rendering, road following, collision, and required other mission functions as required. Provide final design for Phase III development with improved performance. The developed SAF system should result in significantly improved "Fair Fight" scenario correlation.

PHASE III: Complete system development. Incorporate route finding and performance enhancement modifications. Demonstrate a full scale SAF system. Refine the software into production code.

COMMERCIAL POTENTIAL: The commercial potential will be a run-time license of the modified CGF software to use this capability as part of a delivered training system. The software capability lends itself to the next generation of game engine in the commercial market.

KEYWORDS: Computer Generated Forces (CGF); Sensor Texture; Joint Integrated Mission Model (JIMM); Human -in-the-Loop Simulation; Semi-Automated Forces (SAF); Texel

N01-160 TITLE: Aluminum Honeycomb Panel/Substructure Replacement Initiative

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a cost-effective process for the fabrication of aircraft panels and sub-structure (that utilize aluminum honeycomb core construction) that meet, or exceed, the minimal life limit of 60 months for delamination and/or corrosion.

DESCRIPTION: The F-14 and EA-6B aircraft make extensive use of a structural fabrication technique known as honeycomb sandwich construction in the manufacture of flight control surfaces and aircraft sub-structures. The design consists of two thin aluminum (or titanium) skins bonded using adhesive to an aluminum honeycomb core. This construction method provides the optimum mix of lightweight and structural strength; however, these components routinely suffer from core corrosion and skin delamination due to water intrusion, improper workmanship, damaging maintenance actions, and normal environmental stress. Honeycomb bonded panels are expensive to maintain and are repaired or refurbished on a regular basis at the Navy depots. Current approaches only allow for the use of remanufactured panels. This is costly and leads to additional failures over time. The goal of this initiative is to analyze, design, and develop alternative processes for replacement aluminum and titanium skins and honeycomb core that will resist corrosion and delamination for up to 60 months. It also seeks to determine the cost-effective use of a "drop in" core that will greatly streamline the panel/sub-structure manufacturing process. The contractor must take into consideration the use of such materials as aluminum and titanium in the fabrication of replacement skin panels. The contractor's approach must address the qualification of adhesives and bonding materials if they differ from those used in the current fabrication process.

PHASE I: Develop the feasibility of a cost-effective process for the fabrication of replacement of sub-core aluminum materials. Propose changes to existing process specifications and identify qualification test requirements for the recommended fabrication process.

PHASE II: Develop the process for fabrication of replacement sub-core aluminum materials and re-qualify changes to the existing process specification. All processes that have been recommended during Phase I will be fully evaluated and verified by test case. Include all qualification testing such as laboratory, installed ground, and flight-testing. The result of this phase is a detailed process for the fabrication of replacement skin panels.

PHASE III: Restore all aircraft flight control surfaces and substructures for the F-14 and EA-6B that have been qualified during Phase II. Perform initial Fleet reliability tests.

COMMERCIAL POTENTIAL: The aerospace industry is faced with the same problems and issues related to aircraft flight control surfaces as the F-14 and EA-6B aircraft. The problem of commercial aviation is worse due to the high amount of flight hours placed on the airframe and the need to meet the highest safety. Many older commercial aircraft such as the Boeing 707, 727 and 737 series of aircraft have expected service lives of 30+ years. Some of these aircraft are out of production and the ability to find ready replacement panels at reasonable costs or cannibalize skin panels from out-of-service aircraft makes this technology appealing to the original equipment manufacturer and second sources. Additionally, lightweight aluminum sub-cores can be used in the construction industry where structural strength and durability as well as reduced weight are necessary elements of design (such as glass atriums and large dome construction).

REFERENCES:

1. "Corrosion and Corrosion Fatigue of Aircraft Materials" – Lehigh University, Bethlehem, PA, R.P. Wei and D.G. Harlow, Feb 96, NTIS AD-A307 471/3INZ
2. "Fretting Corrosion in Airframe Riveted and Pinned Connections" – Vanderbilt University, Nashville, TN, G.T. Hahn and G.A. Rubin, Mar 98, NTIS AD-A341 669/0INZ

KEYWORDS: Aluminum Honeycomb Core; Aircraft Skins; Adhesive; Delamination; Corrosion; Sandwich Construction

N01-161 TITLE: Active and Passive Reduction of Noise Caused by Bone Conduction to the Head of U.S. Navy Deck Crew Personnel with Helmets

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0, (Program Management for Acquisition and Operations)

OBJECTIVE: U.S. Navy personnel performing aircraft operations (or maintenance) on the deck of the ship are exposed to excessive noise from the aircraft engines during catapult launches with aircraft operating at full after burner, arresting gear recoveries, when full after burner is again applied, or during AV-8B short take off and vertical landing (STOVL) operations on "L" class ships. The levels of noise are so high that the aircraft noise is not only transmitted through the air to the deck crew's ear canal, but it also conducted to the person's skull and through the bone structure to the inner ear. The need to carefully quantify bone and conduction pathways in the human head as a function of frequency is sought. Pathways of conduction need to be carefully mapped. New technology is sought for hearing protection to reduce or attempt to eliminate bone-conducted noise that interferes with speech intelligibility and causes hearing loss to warfighter personnel. New ideas are sought to provide technology in the various forms that can be used with existing deck crew protective equipment. Compatibility with electromagnetic interference (EMI) generated by the ship or the aircraft is important. The reduction of noise to the deck crew person's ear caused by bone conduction is the objective of this program.

DESCRIPTION: Current U.S. Navy deck crew helmets (usually referred to as "cranials") use a circum-aural passive hearing protector consisting of an ear cup assembly with ear seal or cushion. Most deck crew helmets do not have communications equipment. Some personnel who operate near the catapult launching systems on the Nimitz class aircraft carriers experience excessive noise and vibration during the launch of a tactical aircraft with full engine after burners lighted. There is currently no protection available to mitigate this excessive sound pressure and the resulting conduction of the noise internally to the inner ear. Further, the conductive path(s) through the body to the ear are not documented or understood. Ear cup and earplug technology do not appear to help dampen this type of noise. Deck crew personnel currently use double hearing protection by inserting foam earplugs into the ear canal and then donning their helmet with passive ear cup assemblies. The use of full body suits to dampen the vibration has been discussed, but its use is not feasible in a wartime operation in a high temperature region of the world. Application of sensors or active vibration control in a cranial device has been considered, but the proper locations of the sensors are in question. Frontal areas of the face would be difficult to protect since vision and field of view are important. As new high performance aircraft are added to the Fleet, the noise generated by their more powerful engines is producing more noise on the deck of the ship. For the purpose of this program, 85-dB (A) for a maximum of 8 hours per day with 3 dB doubling will be used as the allowable threshold. This will assume that the personnel will be exposed to at least 16 hours of "quiet time" each day. Some deck crew personnel operate in overall noise levels up to 150 dB (A) (ambient unprotected levels) during aircraft launches with after burner operational and aircraft arresting gear recoveries. Some of these personnel are required to conduct voice communications with the air operations officers in the "Island" of the ship. Current deck crew helmets (cranials) when combined with off-the-shelf foam earplugs can provide up to approximately 30 dB (A) of protection. The Naval Aviation Systems Command will provide reports of the latest noise measurements taken on the ground and on a carrier and Landing Ship, Helicopter Assault (LHA) class ship if they are releasable to the public. A system approach that addresses the bone conduction noise problems as described above is sought.

PHASE I: Propose new design approaches to protect naval deck crew personnel from the conduction of noise through the skull to the inner ear. Establish a protocol for determining the path(s) of bone-conducted noise to the human's inner ear. Develop a preliminary conceptual design for deck crew personnel.

PHASE II: Map the path of the bone conduction to the inner ear and document with testing and a report. Perform a trade study and prepare concepts that are believed to provide bone conductive attenuation for deck crew personnel exposed to 150 dB (A). Develop conceptual designs of the phase I approaches and fabricate two prototypes. Prototypes shall be fabricated and preliminary testing conducted to verify that the bone conduction could be reduced or eliminated.

PHASE III: The developed prototypes will be evaluated with existing deck crew helmets (cranials) and tested in the fleet by the U.S. Navy. After successful demonstration and acceptance by the fleet, additional work will be pursued to integrate the technology into the existing personal protective equipment worn by the flight deck crew. This technology will also be shared with the selected Joint Strike Fighter (JSF) and other advanced helmet contractors for implementation into their proposed future helmet systems.

COMMERCIAL POTENTIAL: Foreign military service personnel with aircraft carriers are in need of equipment that can reduce bone conduction caused by high noise. The technology could also be used by commercial contractors using heavy industrial equipment such as "jack hammers" which generate excessive noise.

REFERENCES:

1. ANSI S12.6-1997, "Methods for Measuring the Real-Ear Attenuation of Hearing Protectors"

2. "Bibliography On Hearing Protection, Hearing Conservation, and Aural Care, Hygiene and Physiology, 1831-1999"; E-A-R 82-6/HP, E.H. Berger, M.S., January 25, 1999
3. "The Noise Manual", Fifth Edition , The American Industrial Hygiene Association, May 2000

KEYWORDS: Bone Conduction; Noise Conduction; Active Hearing Protection; Cranial Conduction; Controlling Noise Conduction; Human Skull

N01-162 TITLE: Active Noise Reduction Earplug and Improved Speech Intelligibility for Aircrew and Deck Crew Personnel with Helmet Integrated Communication Systems

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0, (Program Management for Acquisition and Operations)

OBJECTIVE: Speech communication systems used by U.S. Navy and Marine Corps personnel in the aircraft cockpit and aircraft operations (or maintainer) personnel on the deck of the ship are extremely difficult to understand due to excessive background noise from the aircraft engines, environmental control system (ECS) equipment in the cockpit, and wind noise over the canopy or over the deck of the ship. New active noise reduction communication systems (active earplugs and other new technology) combined with passive hearing protective/attenuation technology is sought to reduce or attempt to eliminate ambient noise that interferes with speech intelligibility and causes hearing loss to warfighter personnel. New ideas and technology are sought to provide active noise reduction technology in the form of an earplug that can be inserted under a passive ear cup or helmet assembly. In addition, new hearing protection or sound attenuation technology is needed to reduce ambient noise which leaks past the helmet ear seal and ear cup into the user's ear canal. New earplug designs, better fit, ease of installation by the user with minimal training, repeatable performance in both male and female personnel of diverse races and ages, improved communications, compatibility with electromagnetic interference (EMI) generated by the ship or the aircraft, and the reduction of noise to the user's ear canal during speech communications by both the aircrew and the deck crew personnel are the objectives.

DESCRIPTION: Current U.S. military helmets use a circum-aural passive hearing protector consisting of an ear cup assembly with ear seal or pad and incorporate communication earphone elements at each ear cup and a microphone mounted to the helmet to permit voice communications. In some cases, aviation personnel and deck crew personnel use double hearing protection by inserting foam earplugs into the ear canal and then donning their helmet with passive ear cup assemblies and earphone elements. This additional protection requires them to increase the volume of their communication system and the speech communications is distorted. In addition, the very high levels of ambient noise generated by operational aircraft on the deck of the ship are fed back through the microphone. As new high-performance aircraft are added to the Fleet, the noise generated by their more powerful engines is producing more noise both on the deck of the ship and in the aircraft cockpit. This makes speech intelligibility difficult and can result in permanent hearing damage to these personnel depending upon the exposure levels and the duration of exposure. For the purpose of this program, 85 dB (A) for a maximum of 8 hours per day with 3 dB doubling will be used as the allowable threshold. This will assume that the personnel will be exposed to at least 16 hours of "quiet time" each day. Some deck crew personnel operate in overall noise levels up to 150 dB (A) (ambient unprotected levels) during aircraft launches with after burner operational and aircraft arresting gear recoveries. Some of these personnel are required to conduct voice communications with the air operations officers in the "Island" of the ship. Aircrew personnel in the cockpit can operate in overall noise levels up to 120 dB (A) (ambient unprotected noise) caused by a combination of engine noise, ECS noise and wind noise. Some aircrew personnel use foam earplugs in addition to the helmet, however this requires them to increase the volume of the communication system and speech intelligibility is sacrificed. Current deck crew helmets (cranials) when combined with off-the-shelf foam earplugs can provide up to approximately 30-dB (A) of protection. However, communication speech intelligibility is also compromised by the use of the standard foam earplug. All aircrew personnel in cockpits and deck crew personnel for the purpose of this program use helmet mounted communication systems. The Naval Aviation Systems Command will provide reports of the latest noise measurements taken on the ground and on a carrier and Landing Ship, Helicopter assault (LHA) class ship if they are releasable to the public. A system approach that improves the hearing protection and speech intelligibility for users that operate with communications as described above is sought. Approaches combining active earplug technology with passive technology are encouraged. Protective equipment that is easy to don and doff and to fit to the user with minimum training is very important. Equipment compatibility with aircraft and ship electromagnetic interference (EMI) is very important. Combinations of different hearing protection and speech intelligibility technologies to obtain at least 50 dB (A) attenuation at the user's ear for the deck crew personnel (with communications) and at least 40 dB (A) for the aircrew personnel with communications is the requirement of this program.

PHASE I: Propose new design approaches using existing technology for hearing protection to be worn by naval aviators and deck crew personnel who use communication systems. This shall address both microphone and active noise reduction (ANR) technology as well as improved ear seal and ear cup designs. Identify the difference in performance between custom-fit and

foam earplugs. Compare new types of proven materials available, different types of aviator communication systems, new technology ideas, and mixes of different attenuation technologies. Fit to all users (male, female, various races, various ages) should be addressed. Data on new speech intelligibility technologies shall be included in the study along with the proposed recommended hearing protection. A conceptual design shall be developed for deck crew personnel with communications at the completion of Phase I.

PHASE II: Perform a trade study of aircrew hearing protective systems that provide at least 40 dB (A) of attenuation for the aircrew personnel with communication systems and a minimum of 50 dB (A) of attenuation for deck crew personnel without communications shall be used to develop demonstrable prototypes. Develop detailed designs for the phase I concept and fabricate two prototypes. According to the United States Navy defined frequency spectrum, prototypes of these configurations shall be fabricated and preliminary testing conducted to verify the speech intelligibility per ANSI S3.2-1989 (R1999) and noise attenuation per ANSI S12.6-1997 (Real Ear Attenuation at Threshold) per USN defined frequency spectrum. Six final systems shall be fabricated for government evaluation on deck crew and aircrew personnel in the fleet.

PHASE III: The developed system(s), one with communications for the aircrew and one for deck crew without communications, will be integrated into the existing helmets and tested in the Fleet. After successful demonstration and acceptance by the Fleet, an ECP to the existing personal protective equipment will be prepared to transition this equipment into the Fleet. This technology will also be shared with the selected Joint Strike Fighter (JSF) and other advanced helmet contractors for implementation into there proposed future helmet systems.

COMMERCIAL POTENTIAL: Commercial aircraft pilots and ground crew personnel using communication systems are currently in need of new improved hearing protective equipment that provides improved speech intelligibility. All the U.S. and foreign military service personnel are in need of new or improved hearing protective communication equipment. The technology could also be useable by homeowners who wish to listen to music with minimal background noise and commercial contractors using heavy industrial equipment that generate excessive noise.

REFERENCES:

1. ANSI S3.2-1989 (R1999), "Method for Measuring the Intelligibility of Speech Over Communications Systems"
2. ANSI S12.6-1997, "Methods for Measuring the Real-ear Attenuation of Hearing Protectors"
3. "Bibliography On Hearing Protection, Hearing Conservation, and Aural Care, Hygiene and Physiology, 1831-1999"; E-A-R 82-6/HP, E.H. Berger, M.S., January 25, 1999
4. "The Noise Manual", 5th Edition, The American Industrial Hygiene Association, May 2000

KEYWORDS: Active Noise Reduction (ANR); Active Hearing Protection; ANR Earplugs; Speech Intelligibility; Improved Communications, Helmet Integrated Communication Systems

N01-163 TITLE: High-Voltage Cables and Connector

TECHNOLOGY AREAS: Materials/Processes, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PEO-T, Tactical Aircraft Programs

OBJECTIVE: Develop a compact high-voltage cable and connectors rated to 8 kV capable of withstanding extreme environments experienced in airborne and shipboard military and commercial applications. The effort is specifically focused on solving the high failure rate of present cable/connectors experienced by the Integrated Defense Electronics Countermeasures (IDECM) ALE-55 Fiber Optic Towed Decoy (FOTD) program aboard the F/A-18E/F aircraft.

DESCRIPTION: Develop a high-voltage cable and connector capable of conducting 8 kV of electrical power to the decoy. The proposed cable should be lightweight and not use more volume than the current towline. The towline must withstand the gravitational force place on it by the maneuvering of the aircraft and able to survive the high temperature created by the engine exhaust. The towline must not be susceptible to radio frequency energy coupling which can cause the decoy to function incorrectly. The cable and connectors must be capable of maintaining high signal integrity (i.e. minimal electrical signal transmission loss) over the useful life cycle of the ALE-55 system while requiring minimal maintenance support. The cable/connector system's airborne operating environmental requirements include a high number of maintenance cycles, extreme hot and cold temperatures at high altitude with intense vibration levels and harsh contaminates. The proposed cable must be able to be extended (deployed) at sub- and supersonic speeds.

PHASE I: Perform a feasibility study to re-establish the design criteria for a cable which will provide a high mean time between failure (MTBF) while operating under extreme conditions. Recommend a solution that encompasses the critical material and design criteria. Recommend an innovative design that outlines the connector/cable material and structural design requirements.

Provide a design concept that is capable of being demonstrated in Phase II, and that provides the performance necessary to be considered for application into the ALE-55 FOTD program as a solution to current connector/cable performance shortfalls.

PHASE II: Assemble and test a connector/cable engineering design model in order to demonstrate the system's ability to meet above stated performance requirements (i.e. details of which will be fully developed as part of Phase I). Expand the connector/cable design to include F/A-18E/F ALE-55 FOTD temperature/vibration/pressure environmental requirements.

PHASE III: Develop a prototype and demonstrate the connector's ability to satisfy the requirement established in Phase II. Solicit government/commercial agencies and users to invest in developing a prototype that will be compliant with ALE-55 FOTD System as a precursor to government funded flight tests.

COMMERCIAL POTENTIAL: Commercial miniature high-voltage cable and connectors for use in limited space environments.

REFERENCES:

1. http://www.raytheon.com/es/esproducts/ses050/ses050.htm
2. http://www.dote.osd.mil/reports/FY96/96IDECM.html
3. http://www.janes.com/defence/market_review/jrew_2000_2001/radar_and_electronic_warfare_2000-2001_06.shtml
4. http://www.fas.org/man/dod-101/sys/ac/equip/an-ale-50.htm
5. http://www.airforce-technology.com/projects/fa18/

KEYWORDS: High Voltage; Connectors; Miniature Towline Cable; ALE-55; FOTD; IDECM

N01-164 TITLE: Fiber Optic Cables and Connectors

TECHNOLOGY AREAS: Materials/Processes, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-T, Tactical Aircraft Programs

OBJECTIVE: Develop a compact, high durability, fiber optic cable capable of withstanding extreme environments of airborne and shipboard military and commercial applications. The effort is specifically focused on solving the high failure rate of present cable/connectors experienced by the Integrated Defense Electronics Countermeasures (IDECM) ALE-55 Fiber Optic Towed Decoy (FOTD) program aboard the F/A-18E/F aircraft.

DESCRIPTION: The fiber optic cable and connectors must be capable of operating within the harsh operational environment of the ALE-55 FOTD system as installed on the F/A-18E/F aircraft. The cable will be used to provide communications with the decoy and transmit laser energy to the decoy to provide jamming information. The cable and connectors must be capable of maintaining high signal integrity (i.e., minimal electrical signal transmission loss) over the useful life cycle of the ALE-55 system while requiring minimal maintenance support. The cable should be strong enough to withstand the gravitational forces placed on it by the movement of the aircraft and able to withstand high temperatures from the engine exhaust without premature degradation and failure. The cable/connector system's airborne operating environmental requirements include a high number of maintenance cycles, extreme hot and cold temperatures at high altitude with intense vibration levels and harsh contaminates. This cable must be able to be extended (deployed) at sub- and supersonic speeds and be lightweight.

PHASE I: Perform a feasibility study to re-establish the design criteria for a cable which will provide a high mean time between failure (MTBF) while operating under extreme conditions. Recommend a solution that encompasses the critical material and design criteria. Recommend an innovative design that outlines the connector/cable material and structural design requirements. Provide a design concept that is capable of being demonstrated in Phase II, and that provides the performance necessary to be considered for application into the ALE-55 FOTD program as a solution to current connector/cable performance shortfalls.

PHASE II: Assemble and test a connector/cable engineering design model in order to demonstrate the system's ability to meet above stated performance requirements (i.e. details of which will be fully developed as part of Phase I). Expand the connector/cable design to include F/A-18E/F ALE-55 FOTD temperature/vibration/pressure environmental requirements.

PHASE III: Develop a prototype and demonstrate the connector's ability to satisfy the requirement established in Phase II. Solicit government/commercial agencies and users to invest in developing a prototype that will be compliant with ALE-55 FOTD System as a precursor to government funded flight tests.

COMMERCIAL POTENTIAL: Commercial fiber optic cable and connectors for use in limited space environments.

REFERENCES:

1. http://www.raytheon.com/es/esproducts/ses050/ses050.htm

2. http://www.dote.osd.mil/reports/FY96/96IDECM.html
3. http://www.janes.com/defence/market_review/jrew_2000_2001/radar_and_electronic_warfare_2000-2001_06.shtml
4. http://www.fas.org/man/dod-101/sys/ac/equip/an-ale-50.htm
5. http://www.airforce-technology.com/projects/fa18/

KEYWORDS: Fiber Optic; ALE-55; Cable; Decoy; Integrated Defense Electronics Countermeasures (IDECM)

N01-165 TITLE: Corrosion/Erosion Resistant Coatings for Turbine Compression Systems

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO-A, (Air, ASW, Assault & Special Mission)

OBJECTIVE: Develop a corrosion/erosion resistance coating that can be applied to gas turbine compression systems that operate in a naval environment (salt air, steam sand, and dust ingestion) that will increase engine durability and maintain operational engine performance.

DESCRIPTION: Engine erosion and corrosion of compressor blades and vanes has been a critical degrader to the health of the gas turbine engine fleet for naval applications. During Desert Storm, the H-53 helicopters were near grounding due to severe compressor erosion in sand environments. The H-46 engine fleet has to redesign the material system of the compressor systems due to corrosion of the airfoils. Several other engine families also exhibit this compressor airfoil problem. This translates to a high compressor airfoil scrap rate (about $2M per year for the H-53), more frequent engine overhauls, and an appreciable engine performance reduction with operational time. The Department of Defense-sponsored Foreign Comparative Test Program is completing a two-year effort in which an advanced titanium nitride coating was investigated for application to the U.S. military fleet. As a result of the program, 70 percent of the more conventional compressor material stages will be coated in the H-53 fleet. Several other engines are also investigating the coating for application to their compressor airfoils. Additional research needs to be done on applying these coatings to new and advanced base material systems under development and advanced engine configurations such as integral bladed disks (blisks).

PHASE I: Assess the feasibility and practicality of corrosion/erosion resistant coating systems for advanced compressor material systems and configurations with little degradation to the material system. Define application techniques and characterize the coating system's composition and performance on advanced material systems and compressor blisk configurations. Identify coating(s) and coating process(es) for development in Phase II.

PHASE II: Develop coating(s) and coating process(es). Apply the coatings to test coupons and conduct sand erosion and salt water corrosion tests to validate the coating's performance in a naval environment. Conduct blade fatigue tests to determine the high cycle fatigue (HCF) capability of a coated blade/vane sets. Compare results against other know coating systems. Coat the accelerated simulated mission endurance test (ASMET) compressor section and test the coatings system performance in an integrated engine. (The government will provide the compressor hardware for coating and the ASMET engine for the test.) Identify the coating and coating process for final development in Phase III.

PHASE III: Finalize the coating and coating process. Coat a compressor section of a "Lead the Fleet" aircraft for operational field-testing.

COMMERCIAL POTENTIAL: Aircraft gas turbine technology is vital to the U.S. industrial base. Aircraft gas turbine technology is generally applicable to both military and civilian engines. There is application potential of coatings to a broad range of air, ship, and automotive vehicles.

KEYWORDS: Propulsion; Gas Turbines; Aircraft Engines; Materials; Compressors; Protective Erosion/Corrosion Resistant Coatings

N01-166 TITLE: Multi-Channel Electronic Scanning Module for an Ultrahigh Frequency (UHF) Circular Array

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-T

OBJECTIVE: Develop a modular unit capable of exciting a circular 50- to 60-element UHF electronically scanned array. The unit must maximize the power available from a 50- to 60-channel transmitter and provide a taper across an arbitrary set of adjacent elements (nominally one-half of the array).

DESCRIPTION: The UHF electronically scanned array (UESA) was designed to significantly enhance the capabilities of the Navy's airborne radar platformthe E2-C. UESA is a non-rotating circular array of 50 to 60 end-fire elements designed to provide unprecedented beam agility. Electronic scanning is implemented by dynamically routing the excitation from a 50- to 60-channel transmitter to a subset of adjacent elements consisting of one-half of the array. On a pulse-to-pulse basis, the desired scanning module will enable UESA to form a beam along any azimuth, regardless of prior beam position. In addition, the scanning module must be able to taper the excitation while utilizing the maximum available power from the 10-kW/channel transmitter. The dynamic range of excitation should be in excess of 20 dB. Designs that show the greatest potential for size and weight reduction will be favored.

PHASE I: Provide a design concept, including theoretical performance specifications, which would be prototyped and demonstrated during Phase II. Electrical specifications should include Voltage Standing Wave Radio (VSWR), insertion loss, power handling, switching time, switching ratio/isolation, and excitation dynamic range. Thermal specifications should include cooling requirements and mechanical specifications should at least include projected size and weight.

PHASE II: Finalize the design and fabricate a functional subset of the 50- to 60-channel electronic scanning module to demonstrate the performance of the proposed system. Performance tests addressing the specifications reported in Phase I should be conducted.

PHASE III: Develop ways to decrease manufacturing costs. Fabricate and deliver up to 40 sets of the scanning module. Consider the scanning module for lower power and higher frequency civilian and military communications systems using circular arrays.

COMMERCIAL POTENTIAL: Aircraft prime contractors for Naval and Air Force airborne radar platforms, foreign military, wireless networking industry, cellular base stations, and any solution provider of secure/non-secure communications that require jamming immunity, low probability of interception, or dynamic beam agility and management.

REFERENCES:

1. M. Zatman, B. Freburger, D. Rabideau, "Circular Array STAP," 7th Annual ASAP '99 Workshop, March 10th, 1999. http://www.ll.mit.edu/asap/asap_99/abstract/7.html
2. J. M. Stamm, M. W. Jacobs, and J. K. Breakall, "Comparison of Calculations and Measurements of an Electronically Scanned Circular Array", 16th Annual Review of Progress in Applied Computational Electromagnetics, Naval Postgraduate School, Monterey, CA, 2000.

KEYWORDS: E2-C; Radar; Circular Array; UHF Electronically Scanned Array (UESA); Electronic Scanning, Sensors

N01-167 TITLE: Fuel Reformulation to Reduce Contaminants

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter (JSF)

OBJECTIVE: Develop a cleaner fuel so that high performance engines can run cleaner and criteria pollutants in the emissions, regulated by the Clean Air Act, will be reduced.

DESCRIPTION: Many of the naval bases proposed to accept deployment of the Joint Strike Fighter (JSF) are in non-attainment of the National Ambient Air Quality Standard (NAAQS) for the emissions of ozone precursors: oxides of nitrogen (NOx) and reactive volatile organic compounds (VOCs). The emissions of particulate matter are also of concern since a number of the naval bases are in areas that are classified as in non-attainment for PM10 (particulate matter of 10 microns or less). Gas turbine engines and ground support equipment are a major source of particulates and soot. The United States military consumes between 4 and 5 billion gallons of hydrocarbon based jet fuel per year. Particulate emissions and soot lead to increased engine and fuel system components maintenance cost, decreased engine life, and decreased aircraft/engine availability.

PHASE I: Investigate ways of reducing contaminants in JP-8 and JP-5 fuels by developing cleaner refining processes, developing more efficient filters, or reformulating the fuel.

PHASE II: Provide details of process/es that reduce emissions most successfully. Determine emission reduction for each potential technology.

PHASE III: The emission reduction equipment or fuel reformulation, upon meeting JSF program requirements, will be transitioned to the Preliminary Weapon System Concept (PWSC) and JSF community for potential use. The maintenance procedures and instructions will be updated accordingly.

COMMERCIAL POTENTIAL: Engine emissions are a problem both in the private sector and DoD. The commercial sector is even more heavily regulated than the DoD. A successful reformulation of fuel, or the use of equipment to reduce emissions, could be used by a large portion of the military systems with the potential for use in commercial aircraft as well.

REFERENCES:

1. MIL-DTL-5624, TURBINE FUEL, AVIATION, GRADES JP-4, JP-5, AND JP-5/JP-8 ST dated 18 Sep 1998

KEYWORDS: Fuel; JP-8; JP-5; Emissions; Reformulation; Aircraft Engine

N01-168 TITLE: Thin Layered Damping Treatments for Turbo Machinery

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter (JSF)

OBJECTIVE: Develop a process to apply a thin layered material on the order of 0.001" or less to blading of gas turbine engines in order to reduce vibrations of these components.

DESCRIPTION: State-of-the-art designs of compressor and turbine rotors for aircraft gas turbine engines, are using integrally bladed rotor technologies (rotor and blades are one piece – continuous structure). The advantage of this one-piece construction is weight savings and reduced losses from cavity flows inherent with a bladed disk (inserted blades). The disadvantage comes from the reduction of overall damping provided by the friction interface at the blade/disk attachment. Therefore, the integrally bladed rotor has less damping and is more susceptible to fatigue failures. One approach to reduce fatigue failures is constrained layer damping with viscoelastic materials. In the past, these constraining layers were on the order of 0.030" thick. However, new manufacturing and deposition processes create the possibility of constraining layers on the order of 0.001" thick with the viscoelastic materials on the order of micro-inches. This SBIR will pursue manufacturing and deposition process technologies; such as cold rolling of titanium and plasma deposition of viscoelastic material, to achieve constraining layer damping treatments for integrally bladed rotors on the order of 0.001" thick.

PHASE I: Assess the applicability, feasibility and practicality of thin layered materials (on the order of 0.001"thick) for damping integrally bladed rotors. Identify manufacturing processes capable of applying thin constraining layers of titanium and nickel based alloys for the integrally bladed rotor application. Identify deposition processes capable of applying thin layers of viscoelastic materials for the integrally bladed rotor application. Identify material(s) and process(es) for development in Phase II.

PHASE II: Develop the damping material and the manufacturing/deposition process. Demonstrate the ability to apply a thin layer of damping material on beam and blade test specimens (substrate (rotor material) with similar geometry). Apply a thin layer to an integrally bladed rotor and conduct static and spin tests to determine damping effects, wear characteristics and life of the thin layer, and any chemical/physical interaction between the rotor substrate and thin layer material. Finalize Phase III application process and material development requirements. (Notes: (1) At the end of Phase I, the number of test specimens and rotors to be provided for Phase II will be identified. (2) The Navy will provide spin test facilities.)

PHASE III: Complete process development. Apply thin layer material to an integrally bladed turbine rotor. Conduct full-scale demonstration in a gas turbine engine. (The Navy will provide the turbine rotor and coordinate the test with the engine manufacturer.)

COMMERCIAL POTENTIAL: Thin layered damping treatments are sought after in all fields of turbo machinery. This includes commercial aviation in which aerodynamics of surface conditions are important as is the thickness of the damping treatment so as to not detrimentally effect the engine's efficiency.

REFERENCES:

1. Ross, D., E. Ungar, and E. M. Kerwin, "Damping of Plate Flexural Vibrations by Means of Viscoelastic Laminates", Proc. Structural Damping ASME, pp. 49-87, 1959
2. Jones, D., "Materials for Vibration Control in Engineering", Shock and Vibration Bulletin, 43, pp. 145-151, 1973.

KEYWORDS: Integrated Bladed Rotor; Rotor Damping; Deposition Process; Viscoelastic Materials; Turbo Machinery; High Temperature Alloys

N01-169 TITLE: Non-Mechanical Beam Steering for Infrared Countermeasure (IRCM) Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PEO-T

OBJECTIVE: Develop a compact scanner that can redirect light (laser or IR image) by non-mechanical means.

DESCRIPTION: The Naval Aviation Systems Team is developing a number of IRCM systems that use lasers to protect aircraft from IR guided threats. Current systems steer the laser energy by mechanically driven mirrors. These mirrors are prone to failure in the extreme vibration environments of a tactical aircraft. They also take up a large fraction of the size and weight allocated for the system. What is needed is a compact/non-mechanical method of redirecting the laser energy, which would simplify and improve the IRCM system. Concepts proposed must support the functions of the tactical directed (DIRCM) concept including a mid-wave infrared receiver/tracker and an open-loop IRCM laser transmitter/beam-director. Concepts must be able to transmit and receive midwave infrared (MWIR) signals over an angular coverage of at least 90 degrees with a one milli-radian degree resolution. Concepts must be able to cover the wavelength range of 1.0 to at least 5 microns, and handle at least 5 watts of laser energy without damage. The system should be able to redirect the laser energy at a rate of at least 5k radians/sec. The goal of this SBIR topic is to develop an IRCM concept that is practical, affordable and compact enough to fit into existing IRCM jamming systems. Proposals will be ranked on complexity, cost and practicality.

PHASE I: Perform a concept design and feasibility study that will address the following areas: a) optical transmission over the entire mid-IR band; b) speed or bandwidth for tracking; c) size, weight, power, and cost estimates; and d) aperture and wave front error.

PHASE II: Build a prototype and perform the requisite analyses for future integration in to an existing CM system. The system will be tested in the laboratory and ground tested at long-range to demonstrate acceptable performance.

PHASE III: Upon successful completion of the Phase II effort, the system will transition to PMA-272 for integration into a defensive system being developed for tactical fixed and rotary wing aircraft.

COMMERCIAL POTENTIAL: This technology could be used in a laser based remote sensing application: for example, pollution monitoring, oil pipeline leaking detection and in areas where one is trying to detect molecules from a distance. This system could be used for surveillance applications such as non-cooperative air or ground identification for both military and the law enforcement community.

REFERENCES:

1. "TADIRCM Live Fire Test Results," 00 Military Sensing Symposia (MSS) April 00, 9-11 Naval Post-Graduate School, Monterey CA.
2. "Live Fire Testing of WANDA™/VIPER™/MIMS/NEMESIS DIRCM," 00 Military Sensing Symposia (MSS) April 00, 9-11 Naval Post-Graduate School, Monterey CA.

KEYWORDS: Infrared; Infrared Countermeasure; Laser; Tactical Aircraft; Jammer; Directed IR Countermeasures

N01-170 TITLE: New Cooling Technology to Increase Aircraft Generators Power Rating

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II & IC: PEO-A

TITLE: New Cooling Technology to Increase Aircraft Generator Power Rating

OBJECTIVE: Develop and incorporate new and innovative thermal design techniques into existing generator packages. The goal is to significantly increase generator power output on a continual basis without changing the generator size, weight, or other operational parameters.

DESCRIPTION: Navy aircraft are experiencing avionics growth and operational life extensions requiring increased generator power output without affecting the other aircraft systems or structures. Adding a bigger generator is not a solution because it will have a significant affect on engine and accessory gearbox design and other aircraft systems. Present generators are designed with significant overload capacity inherent to the electromagnetic design. They are limited from providing this additional power on a

continual basis due to thermal constraints. New cooling technologies that will increase the generator power output without effecting other aircraft systems are vital to maintaining aging aircraft.

The successful candidate shall demonstrate in the proposal their familiarity with aerospace generator design including the basic understanding of rotational dynamics and electromagnetic design.

An initial generator type will be selected to evaluate the novel cooling technology. A 60 KVA, constant speed, air-cooled generator (used in the P-3, E-2C, C-130, and other Navy aircraft) will be a logical, initial application of novel cooling techniques because of its simple design and a known need for additional electrical power by platforms utilizing this generator type. Proposals are not, however, limited to a specific generator type. Evaluation of other generator types under this effort are encouraged and ultimately all technologies developed under this effort will be applied to a wide variety of machines used in both military and commercial applications.

One possible approach to achieving the program objectives is the incorporation of innovative cooling materials. The Naval Research Laboratory (NRL) is developing a new cooling technology for high power static magnetic elements to increase power output without increasing the magnetic element size. This technology has not been evaluated for use in a dynamic (i.e. rotating) environment. While it is believed that this technique may greatly enhance the thermal efficiency of existing designs and configurations, a variety of cooling techniques are sought.

PHASE I: Define a generator cooling approach and develop an initial design and implementation plan for the selected generator type. Validate the approach analytically or provide test data or bench top hardware that validates the approach. Selected candidates should make maximum use of computer modeling and simulation techniques. The goal is to increase the generator power by 30 to 50%.

PHASE II: Using the selected generator type, develop and demonstrate the generator cooling technology without changing the generator size, weight, or other operational parameters. The generator, which can either be a reworked existing machine or other such suitable prototype, is to be subjected to "proof of concept" testing to verify the increase in generator power rating over full operational ambient conditions. For example, a generator type presently rated for 60/90 kVA will have a minimum rating of 80/90 kVA and, possibly, 90/120 kVA after incorporation of the new cooling technology.

PHASE III: Package and integrate the new generator cooling technology for use in an aircraft generating system. The unit(s) should be subjected to full qualification testing and flight-test profiles.

COMMERCIAL POTENTIAL: The novel cooling technology developed under this effort will have widespread application in commercial electromagnetic devices such as generators and transformers. This technology will provide a substantial increase in power density for electromagnetic devices that will result in smaller size and weight or increased power capacity. Commercial airlines are specifically interested in increasing the power density of electromagnetic devices utilized in generation, distribution, and avionics components. The results of this effort will be equally beneficial to consumer products and industrial applications because of improvements in thermal efficiency and reliability.

REFERENCES:

1. Eddie Sines, " Electric Power Cooling Technique," Navy Patent Pending Case Number 79955, 1999.

KEYWORDS: Generator; Cooling; Power Density; Avionics; Electrical Power; Magnetics

N01-171 TITLE: Visualization and Quantification System for Modeling Unsteady Aerodynamics for Aircraft Simulations

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-T

TITLE: Quantitative Flow Visualization/Measurement System for Modeling Unsteady Aerodynamics in a Water/Wind Tunnel

OBJECTIVE: Develop a methodology, hardware and/or instrumentation to simultaneous visualize and measure unsteady flow phenomena in a water and/or wind tunnel. The proposed method should measure forces and moments and concurrently obtain quantitative flow visualization data of unsteady aircraft behavior during water/wind tunnel testing. The quantitative flow visualization will be used to corroborate traditional force and moment measurements and aid in creating physically representative aerodynamic models based on those measurements.

DESCRIPTION: Current aircraft aerodynamic models, as used in simulation and in control law development, are weak in the area of unsteady aerodynamics. This is due to the high cost associated in acquiring high fidelity data or difficulty in understanding the correlation between lower fidelity force and moment measurements and the associated unsteady flow phenomenon. Develop and demonstrate a water/wind tunnel test technique that measures aerodynamic forces and moments (through use of balance, pressure taps, or other technique) while concurrently conducting quantitative flow field visualization during unsteady flow conditions. The quantitative flow field visualization will be used to corroborate force and moment measurements and capture off-body flow characteristics for use in generating accurate unsteady regime aerodynamic models. Such models could then be incorporated into existing simulation databases for use in supporting engineering simulations and fleet trainers, reducing engineering efforts and flight test costs as well as improving pilot training fidelity.

PHASE I: Determine the feasibility of using a novel methodology, hardware and or instrumentation that will tie together quantitative visualization techniques with traditional force and moment measurements. The concept should incorporate data from the tunnel, balances, flow visualization equipment, and data acquisition equipment. Develop a test matrix to exercise the system (e.g., sweeps, flow conditions, etc.). The final report should explain how the force/moment and flow visualization data would be used to model the unsteady aerodynamics. This will be used in Phase II to develop higher fidelity mathematical models than are currently in existence in unsteady flow regimes.

PHASE II: Develop a prototype and demonstrate it using a Navy military aircraft model. Use the results (tying together force and moment data with flow visualization data) to formulate mathematical models that are able to accurately predict aircraft response in unsteady flight regimes. Demonstration success will be based on a comparison, in a PC based simulation, of the model developed under this SBIR and an existing model.

PHASE III: Transition the demonstrated technique to aircraft programs for use during design, development, developmental testing and follow-on efforts.

COMMERCIAL POTENTIAL: The correlation of real-time quantitative flow visualization integrated with aerodynamic force and moment measurements during unsteady conditions is an undeveloped capability which could benefit both military and commercial applications. In addition, this technique will potentially aid in the understanding of unsteady phenomenon during traditional static and dynamic testing. Private sector transitions could include design tools for commercial aircraft.

KEYWORDS: Unsteady Aerodynamics; Quantitative Flow Visualization; Aerodynamic Coefficients; Modeling; Dynamic Testing; Vortex flows

N01-172 TITLE: New Mid-Infrared (IR) Laser Materials

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PEO-T

OBJECTIVE: Develop growth and fabrication for rare earth doped chloride laser crystals.

DESCRIPTION: Conventional near-IR solid-state lasers work so well because trivalent rare earth ions can store energy in their electronic configurations for hundreds of microseconds. This allows time for low intensity optical pumping to high levels of excitation and gain. Low concentration neodymium doped oxides, for example, can store the energy for about 200 μs. They produce excellent 1.06-μm lasers when pumped at 0.8μm. Similarly erbium, thulium, and holmium ions yield very useful laser transitions at 1.5, 2.0 and 2.1 μm. However, for rare earth transition wavelengths longer than 3 μm, the storage lifetime falls very rapidly to the nanosecond time-scale. Pumping such short-lived states requires very high intensities, which preclude simple compact lasers.

The process that causes shortened lifetimes at longer wavelengths is called multi-phonon quenching. In this process, excited electronic states decay via the creation of several quantized vibrations in the inter-atomic bonds. This non-radiative decay route deactivates the optically pumped state. Multi-phonon quenching occurs in all solids, but its strength depends exponentially on the energy of the highest frequency optical phonons for each solid. Solids composed of lighter elements have higher phonon energies and exhibit much higher multi-phonon quenching rates. Since all conventional rare earth lasers are based on oxides and fluorides, with phonon energies in the 700 to 400 cm-1 range, they are subject to strong multi-phonon quenching for transitions longer than 3 μm. This is why direct solid-state lasers are not available in the mid-IR.

Recent work has shown that low phonon host materials can enable rare earth lasers. Based on chloride crystals, these materials have maximum phonon energies in the range of 200 – 250 cm-1. Rare earths doped into these crystals exhibit excellent energy storage lifetimes (milliseconds) for transitions out to at least 8 μm. Using these materials, direct mid-IR lasers have been demonstrated without the need for cooling below ambient temperatures. The most promising of these low phonon laser crystals is

KPb2C15. This biaxial crystal is sufficiently hard and stable to enable practical laser sources. This crystal can be grown via vertical Bridgeman techniques and doped with rare earths to at least the 2E20 ion/cc. Crystallization occurs in a melt at 435 °C under a dilute chlorine atmosphere

PHASE I: Conduct experimental growth of KPb2C15 crystals doped with the rare earth erbium. Spectroscopic samples would be evaluated at the Naval Research Laboratory.

PHASE II: Refine growth techniques for the production of clear, oriented crystals of several centimeters in length. Samples would be tested for laser performance at the Naval Research Laboratory.

PHASE III: Improve facilities for production of mid-IR laser crystals for use in DOD laser systems.

COMMERCIAL POTENTIAL: Laser sources in the mid-IR have commercial applications in chemical detection, thermal imagery and surgical systems.

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KEYWORDS: Mid-Infrared Lasers; Rare Earth Lasers; Ternary Chloride Crystals; Compact Lasers; Crystal Growth; Countermeasures

N01-173 TITLE: Non-Explosive Broadband Acoustic Source for Multi-Static Anti-Submarine Warfare (ASW)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-A

OBJECTIVE: Develop a non-explosive command activated broadband acoustic source for multi-static ASW. This source will meet the performance of the existing source, while significantly improving safety with lower cost.

DESCRIPTION: Current sonobuoy broadband sources utilize explosive material to produce a broadband ping. Use of this material requires that part of the sonobuoy be assembled by a qualified explosive manufacturer. The final assembly of the sonobuoy therefore occurs outside the sonobuoy manufacturer's plant. To insure the safety of personnel, strict procedures are instituted for the manufacturing, handling, shipping, and storage of the final sonobuoy assembly. This adds significantly to the life-cycle cost.

This broadband acoustic source concept exploits the advantages of the aluminum-water reaction, specifically its energy efficiency and safety aspects. The aluminum-water reaction is a highly efficient source of energy for two reasons: aluminum-water is nearly four times as energetic per gram as trinitrotoluene (TNT) and seawater provides the oxidizer. Aluminum powder, the primary fuel, is inert until it is combined with water and raised to over 900 degrees Celsius. Consequently, an acoustic source sonobuoy using this technology would require little or no special handling or storage. Technology to reliably control the aluminum-water explosion with a specific pulse length, intensity, and radiation pattern needs to be developed.

PHASE I: Determine the effects of aluminum-water source configurations, aluminum powder grain size, heat rate, water intrusion rate, housing size and charge shape on acoustic parameters in terms of acoustic source level, spectral output, and beam pattern. Select the aluminum-water concept that best matches the acoustic parameters of the current SSQ-110 sonobuoy explosive source. The SSQ-110 sonobuoy is the Navy's latest state-of-the-art sonobuoy.

PHASE II: Develop the design concept proposed in Phase I. The design should include housings, deployment mechanisms, and the ignition and control systems necessary to deploy and direct a broadband acoustic pulse. Fabricate a prototype acoustic source, conduct an ocean field test, and measure the performance of the system in terms of beam width, source level, and acoustic spectral content. The prototype would consist of a line with aluminum capsule charges distributed vertically in an array 65 feet long and a command and control module for electrical power and explosion initiation. Prior to the test, a safety plan is to be

submitted for review and approval. Provide a design concept for the integration of an aluminum-water acoustic source into the existing SSQ-110 sonobuoy configuration including its communication and control systems.

PHASE III: Integrate the aluminum-water source into an SSQ-110 sonobuoy configuration. Conduct full-scale field demonstration of the sonobuoy with an aluminum-water acoustic source. Finalize engineering design and production processes.

COMMERICAL POTENTIAL: This high-energy underwater acoustic source could be used by the oil exploration industry. This technology could find uses in any application requiring highly controllable underwater explosions.

KEYWORDS: Sensors; Impulsive Source; Acoustic Source; Multi-static Anti-Submarine Warfare (ASW); Non-explosive Source; Aluminum Water Reaction

N01-174 TITLE: Wireless Leave-In-Place Aircraft Structural Nondestructive Evaluation (NDE) Sensors

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-A

OBJECTIVE: Develop leave-in-place, small, lightweight nondestructive sensors that can be interrogated and analyzed via wireless/Internet connection for structural health assessment.

DESCRIPTION: Aircraft structural components are often hidden by overlying panels and airframe skin. Corrosion and fatigue damage can go unnoticed until the damage is severe. To avoid the high cost of inspections, there is a need to assess the structural integrity of these components in a noninvasive manner. Often 500 to1500 man-hours are required to inspect structures buried deep within the body of an aircraft. The sensors should be inexpensive since they are mounted permanently in the aircraft and many may be required to fully inspect complex airframe structures. A remote data interrogation capability is important to minimize operational down times associated with NDE inspections. An added benefit of this type of operation is the potential to obtain (near) real-time inspection results while in service. These results would then be communicated to a central point for analysis and historical comparison, and thus assist in preparing aircraft maintenance packages and schedules. The total weight of the system should not exceed 15 pounds, including transmit/receive electronics, for an array of 20 or more sensors. The installed sensor must be reliable. The sensor's life should ideally span that of the aircraft.

PHASE I: Assess the feasibility and practicality of sensors, electronics, and wireless communication systems for use in an aircraft environment to monitor structural health of an aircraft. Prepare a design for a wireless operation/inspection system to be developed in Phase II.

PHASE II: Develop sensors, electronics, and wireless communication systems for aircraft structural components and demonstrate on a breadboard level. The prototype system should include at least 20 leave-in-place sensors with remote data interrogation capability and Internet data communications. Finalize the design of the structural health monitoring system for Phase III.

PHASE III: Conduct a full-scale demonstration in an aircraft. Refine production processes for sensor and communication system.

COMMERCIAL POTENTIAL: Structural integrity in aircraft is a major concern in all flight operations. There is a potentially large market in many industries for a system that is unobtrusive and reliable in operation, low in cost, and does not require expert operators or on-site expertise to interpret the results. In addition to aircraft there are hidden structural members in almost any large industrial plant, including ships, trains, power plants, and any manufacturing operation. The ability to economically inspect and assess structural integrity with no on-site equipment other than a wireless transceiver can affect long term cost savings and reliability improvement – a highly marketable commodity.

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2. Rose, J.L., Soley, L., "Ultrasonic guided waves for the detection of anomalies in aircraft components", Materials Evaluation, Vol. 50, No. 9, Pgs. 1080-1086, September 2000.
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KEYWORDS: In-Situ Sensors; Remote Operating; Fatigue Cracks; Structural Damage; Corrosion; Aircraft System

N01-175 TITLE: CODEC (Code/Decode) for Digital Buoys in a Harsh RF Environment

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PEO-A

OBJECTIVE: Develop Code/Decode scheme to improve the quality, integrity, and performance of data transmission between an ADAR sonobuoy and the tracking aircraft.

DESCRIPTION: The Air Deployable Active Receiver (ADAR) sonobuoy is an underwater array of hydrophones that is used for Antisubmarine Warfare. Electrical impulses from the array are beamformed and then modulated onto an analog RF uplink. The data are sent up in digital format on the uplink. The data are then received on the aircraft by an AN/ARR-78 receiver.

A simulated study recently conducted (Mitre, 3/2000) demonstrated that significant channel interference and fallout occur when interferors occur within the uplink transmission band. The study demonstrated the point at which the bit error rate (BER) exceeded spec and the point at which the receiver lost synchronization.

CODEC is envisioned as using coding/decoding of transmitted data, whether through redundancy, encryption, compression or error correction to address the RFI (Radio Frequency Interference) problem. Because of the sensitivity of the numbers in the Mitre study any contractors responding with a proposal should assume a constant BER specification exceedance number and a constant sync loss number. The emphasis in judging the proposals will be on how an RF carrier with digital information can be protected from interference over long ranges (50 nm) in the presence of interfering noise.

PHASE I: Assess coding/decoding schemes that improve transmission quality for digital data on an analog carrier where the digital data transmission bandwidth is on the order of 10 kHz. Document the feasibility, practicality and risks associated with each coding/decoding scheme. Identify coding/decoding technologies and a scheme for development in Phase II.

PHASE II: Develop the scheme(s) recommended in Phase I. Assemble breadboard transmission and receiver units and install coding/decoding scheme. Demonstrate improved transmission through simulation testing. Identify a design concept for Phase III implementation of the code/decode scheme in the ADAR system

PHASE III: Complete the design. Conduct full-scale demonstration in ADAR sonobuoy system.

COMMERCIAL POTENTIAL: Any system having wireless transmission could benefit from the technology developed under this topic, e.g., other digital sonobuoys, digital cellular phones, satellite transmission, etc.

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KEYWORDS: Code/Decode; Channel; Transmission; Redundancy; Packets; Source; Receiver; Reconstruction

N01-176 TITLE: <u>Fiber Optic Ethernet for Aviation Intercommunications System Voice Transmission</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II, IC: PEO-A

OBJECTIVE: Provide architecture options and feasibility for use of fiber-optic Ethernet protocols for aviation intercommunications systems.

DESCRIPTION: The use of fiber optic technology provides a secure and low-noise physical layer in data buses. Ethernet provides open architecture data bus protocols. However, fiber optic Ethernet protocols use star topologies, which allow a single point of failure at the hub. Thus, it is not desirable in aircraft digital Intercommunication System (ICS) installations. If the star topology could be modified to provide multi-drop architecture, or if some other means could be devised to mitigate the problems inherent in a star architecture, while still maintaining the advantages of the Ethernet protocols for ICS use, the fiber optic network would become much more attractive.

PHASE I: Provide a feasibility study that addresses the problems of fiber optic Ethernet protocols and their applicability in aircraft ICS applications, addressing specifically the problems with a center hub/star architecture. Also, address specifically the

problems with center hub/star architecture. Also, address specifically the transmission of real-time voice over Ethernet and the requirement to run dual redundant buses as a backup measure. Provide a report detailing the findings of the Phase I study.

PHASE II: Provide a working prototype of the architecture selected by the government from the Phase I results.

PHASE III: The transition of this technology will offer ICS options currently available for multi-radio military aviation platforms, offering advantages in weight, power consumption, and security over currently available approaches.

COMMERCIAL POTENTIAL: A fiber optic ethernet could provide a secure, low-noise inter-communication system for commercial aviation applications. This technology could also be applied to reduce factory floor noise in industrial applications.

KEYWORDS: Avionics; Communications; Ethernet; Intercommunications System; Fiber Optics; Data Bus Protocols

N01-177 TITLE: Hydraulic Seal Replacement

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and implement a replacement long-life seal for use in hydraulic, fuel, and environmental control systems

DESCRIPTION: The military aviation community experiences an alarmingly high rate of premature failures in elastomer seals. Leaking hydraulic seals, in particular, account for over 200 million dollars in annual repair costs, primarily because all hydraulic components rely on hydraulic fluid to lubricate and cool the components when in use. When fluid is lost, these components run dry and seize. Many of the components have caught fire and caused collateral damage to the aircraft and surrounding structure. These failures can almost always be attributed to a leaking seal. The hydraulic fluid itself is also a contaminant that contributes to collateral damage. Further, the fluid used in the environmental control system is very corrosive and has been a factor in damage to electronic components within the aircraft. The seals in question are manufactured from a nitrile base compound that tends to lose its elasticity (harden) at temperatures above 200(input degree symbol)F and below 60 (input degree symbol)F. As a result, leakage occurs that is not always detected in time to prevent primary system or collateral damage. This problem affects all military and commercial aviation. Further, these seals become brittle at very low temperatures and can crack resulting in damage. This initiative seeks to develop a replacement seal compound that eliminates all known limitations in temperature extremes and operating fluids. The analysis must include recommendations for alternative long-life seal material that will both maximize durability to withstand the operational environment conditions of the F-14 aircraft and can be cost-effectively implemented. The operational range of the material must be from -90(input degree symbol)F to 350(input degree symbol)oF for a period of 3 hours. The material must have minimal variations in tensile strength and ultimate elongation over the entire temperature range. The material must demonstrate a resistance to abrasion, tearing, and heat aging at temperatures up to 350 (input degree symbol)F. It shall demonstrate the ability to provide excellent metal adhesion in a wide range of applications.

PHASE I: Demonstrate the feasibility of manufacturing a consistent, high quality elastomeric compound for hydraulic seal applications. The seal material must have an operational range from -90(input degree symbol)F to 350(input degree symbol)F for a period of 3 hours. The material must have minimal variations in tensile strength and ultimate elongation over the entire temperature range. The material must be resistant to abrasion, tearing, and heat aging at temperatures up to 350(input degree symbol)F. It should provide excellent metal adhesion in a wide range of applications. Existing seal specifications, which must be modified to incorporate the new compound/technology, will be identified under Phase I.

PHASE II: The results of this phase are a detailed process for the fabrication of the high-temperature elastomeric compound, for hydraulic seal applications, and validation of seal characteristics. Samples of the new batch compound recommended during Phase I will be provided to the seal vendor for fabrication into seal for specific applications (hydraulic fluid, JP-4/5/8/NATO, environmental control systems). Validation tests of the seals, on military aircraft specific applications, must be performed in this phase. First article/prototype tests will be conducted on EA-6B rudder, stabilizer, and flapperon actuator assemblies and F-14 spoiler, rudder, and four-way valve actuator assemblies.

PHASE III: The new seal will be implemented as a preferred spare in all appropriate aircraft applications. Implement procurement of new hydraulic seals using the improved seal compound.

COMMERCIAL POTENTIAL: Commercial aircraft suffer from the same inherent problems in their flight control and hydraulic systems. The development of a new, durable, long-life seal can be directly applied to all military and commercial aviation worldwide. The base polymer compound to be developed under this initiative could be applied to a wide range of heavy industrial, military, ship, and space programs. The material envisioned can be used in gaskets, diaphragms, hoses, shock mounts, foams, coatings, and electrical applications. Its demonstrated structural properties make the elastomer a candidate in biomedical applications and devices. The automobile industry is another candidate for use of this material in engine manufacturing. The base compound elastomer can also be used in the fabrication of artificial skin for use in burn victims.

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KEYWORDS: Elastomer; Nitrile; Seal; Fuel; Environmental Control Systems; Hydraulic Fluid

N01-178 TITLE: Photonic Switching for Aircraft Fiber Optic Networks

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO-T

OBJECTIVE: Develop rugged photonic switching technology for aircraft networks.

DESCRIPTION: A critical component required to implement fail-safe optical interconnects is a high speed switching mechanism. Switching is required for redundancy management in optical networks as well as a data routing mechanism for use in computer architectures. Switching can be done in either the optical or the electronic domain. Today, only electronic switches are being proposed for aerospace platforms due to the low technology readiness level of electro-optic or all optical approaches. The use of wavelength division multiplexing provides for both parallel data transmission with simplified switching complexity. Switching parameters that need to be optimized include throughput, bandwidth, switching speed, power dissipation, packaging density, and fan-out capability. Successful implementation of photonic switching can provide for scaleable networks with built-in fault prediction, isolation, and circumvention by providing in-flight diagnostics and real-time configuration of the cable plant. All optical switching and wavelength division multiplexing provides compatibility with the most commonly proposed network protocol standards and provides the capability to update a platform with higher bandwidth capability and new network protocols as they evolve without the need to replace the switch.

PHASE I: Identify the most promising optical technology to implement both multi-mode and single-mode optical switches for aircraft applications. Complete an analysis of alternative implementations highlighting key performance and environmental properties of the proposed technology and crossbar switch design including hardware and software control mechanisms.

PHASE II: Design, demonstrate, and package a 32 x 32 optical switch compatible with a switched fibrochannel network architecture.

PHASE III: Ruggedize and optimize the optical switch for flight testing in a Navy aircraft.

COMMERCIAL POTENTIAL: All optical switching can apply to optical local area networks as well as industrial control applications.

KEYWORDS: Photonics; Optical Switching; Wavelength Division Multiplexing; Fiber Optic; Networks; Data Transmission

N01-179 TITLE: Low-Cost Dual-Mode (Visible/Infrared) Imager

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PEO-W

OBJECTIVE: Develop and demonstrate low-cost dual-mode imaging sensors

DESCRIPTION: Despite their obvious great military and commercial value, dual-mode visible/infrared imagers have not been constructed historically due to cost and complexity issues. In both military and commercial applications, the need for imaging systems that operate day and night is increasing. Military systems are reverting more and more to autonomous target recognition (ATR) systems to locate targets and guide weapons. Almost all military imagers that perform autonomously have been constructed to operate in the infrared spectral region because infrared provides both daytime and nighttime capability. However,

since the majority of target reference imagery is available only in visible spectral bands, ATR algorithms are often stressed to perform their functions with real-time infrared imagery. Many times, during daytime operation, both the visible and the infrared bands can be used in a synergistic manner. For example, a dual-mode seeker would provide a cross-spectrum check on ATR correlations.

Recent progress in the manufacturing of optical components and advances in uncooled detector technologies have made it possible to construct affordable dual-mode imagers with the same if not better performance as current imagers. Camera housings can be constructed of thermoplastics or other moldable materials. Production methods include injection molding or press molding. Optical components, such as lenses, can be made of moldable materials. Dispersion can be corrected for by use of diffractive elements. Uncooled infrared detector arrays give sensitivity and resolution performance previously available only with expensive cooled array systems. For purposes of this solicitation, the imager is defined to output RS-170 and digitized imagery. To retain compatibility with the majority of weapons and weapons-support systems, the cameras should compactly fit within a 10-inch cube, preferably smaller. As a guideline, respondees may consider diffraction limited resolution of 0.25 milliradian and sensitivity of 0.1oC or less to be responsive to military needs. Commercial needs may or may not differ. Electronic zoom and simultaneous display/processing of infrared and visible images are adjuncts that may be considered in response to this solicitation. Reflective or refractive optical designs are acceptable. In order to fulfill the requirement of low cost, the projected production costs for lots of 1,000 units should not exceed approximately $12-$20K. Cost considerations should be addressed in response to this solicitation.

PHASE I: Provide a design concept for an affordable dual-mode imager employing recent technology improvements to reduce cost without degradation to current performance. Include as many of the technologies associated with the dual-mode imager approach as possible, including the anticipated image quality, whether by a laboratory instrument or simulation. Electronic design and development should also be provided in detail, including a description of signal interfaces.

PHASE II: Implement the concepts of Phase I and demonstrate one or more prototype dual-mode imagers. The Phase II demonstration units must exhibit form-fit-function of the anticipated Phase III all-up deliveries. As much as possible, the prototype units should be environmentally tested in a laboratory environment. Full qualification examinations are not required. However, all risk areas must be satisfactorily addressed by test, simulation, similarity, or analysis. Conduct a detailed cost analysis of the technology and its return on investment.

PHASE III: Produce a limited number of production-representative units for delivery to Government and industrial users for testing.

COMMERCIAL POTENTIAL: The dual-mode imager has many potential commercial applications. These include home security systems; business security systems; anti-terrorist applications; and public building security systems such as schools, court houses, etc. In most applications, the visible is used for daytime or artificially lit scenes and the infrared for smoggy or nighttime conditions. Under many daytime conditions, the visible and infrared images can be correlated with each other to maximize the information gathered.

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3. VITREX Company Literature, "Properties of PEEK Polymer", Web Site www.linkupon.com/linkupon/peek.html, December 2000. (See other web sites under "PEEK")
4. Wyatt, Clair L., "Electro-Optical System Design", McGraw Hill, Inc., 1991, (See especially Ch 12 and 13)
5. Ronm-Haas Company Literature, "CLEARTRAN, Water-clear Form of Zinc Sulfide", Web Site www.cvdmaterials.com/cleartra.html. (See other web sites under "CLEARTRAN")
6. Gonzalez, R.C. and Richard E. Woods, "Digital Image Processing" Addison-Wesley Publishing Company, 1992. (See especially Chapter 9)

KEYWORDS: Imagers; Infrared Sensors; Visible Sensors; Security Systems; Dual-Mode; Seekers

N01-180 TITLE: <u>Low-Cost Global Positioning System (GPS) Oscillator</u>

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PEO-W

OBJECTIVE: Develop a low-cost GPS oscillator that meets military GPS accuracy requirements.

DESCRIPTION: The development of the GPS navigation system has generated a myriad of users including weapons, aircraft, and ships. The GPS receivers, referred to as the user equipment, use a high-quality crystal oscillator to receive and properly interpret the GPS signals from the GPS satellites. This SBIR topic will address the development of a temperature compensated or other low-power oscillator that provides the same quality performance as today's oven controlled crystal oscillators without the size, weight, power, and cost penalties of the oven controlled oscillator.

PHASE I: Develop a crystal oscillator design concept and perform an analysis to verify that the design will meet the following characteristics. The oscillator will cost less than $125 (goal less than $50), use less than two watts of power, support fast response over the standard military temperature range (rated stability within 30 seconds - goal of 3 seconds), and provide good long term stability (2 ppm over 20 yrs) and good short term stability with a threshold of 1.0E -10 root Allan variance at t = 0.1 sec and root Allan variance of 6.0E-11 at t=1.0 sec (goal is 5.0E-11 root Allan variance at t=0.1 sec and root Allan variance of 3.0E-11 at t=1.0 sec). Initiate the design of an engineering prototype oscillator than can be fabricated and tested during Phase II.

PHASE II: Finalize the design. Fabricate and test the selected crystal oscillator concept evolving from the Phase I program. The testing of the engineering prototype should include testing over the entire environment range. Initiate producibility studies of the design along with production planning and design-to-cost analysis. Provide three test articles to the Government for early engineering assessment.

PHASE III: Build 10 production representative units that will be used by the Government for flight test, environmental qualification, and reliability development/growth testing. Provide engineering support via corrective action redesign resulting from the above testing.

COMMERCIAL POTENTIAL: This oscillator design is applicable for any commercial application of GPS that desires low-power utilization combined with rapid response. This oscillator would improve GPS performance where the receiver is subjected to electromagnetic interference such as business aircraft or helicopters flying in and out of populated areas.

KEYWORDS: Global Positioning System (GPS); GPS Receiver; Crystal Oscillator; Navigation System; Electromagnetic Interference; GPS-Aided Weapon Systems

N01-181 TITLE: Automated Strike Package Planning System

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter (JSF)

OBJECTIVE: Develop a prototype system for distributed low observable (LO) strike package planning, dynamic mission management, time critical targeting including aircraft and weapons deconfliction and airspace visualization, that meets the needs of the Joint Armed Services.

DESCRIPTION: Automated strike planning tools are needed to assist LO strike package mission commanders with performing strike package planning at the unit level. Unit-level integrated LO strike package planning is currently performed using mostly a manual process. Mission commanders in operational units expend significant effort in developing an initial strike package plan, coordinating the plan with the flight leads, reviewing the plan, assessing contingencies, preparing briefings, and revising the plan based on last minute changes. The process is essentially performed using STU-IIIs, paper maps, and note pads. The manual planning process is time consuming, inherently error prone, and does not guarantee consistent information dissemination across the units, especially if the units are at different locations. Furthermore, manual planning does not allow air vehicle and weapons deconfliction to be effectively assessed.

Current DOD Mission planning systems and systems under development fail to take advantage of emerging technology and will not be able to address LO requirements because of their architectural failings. It is common for mission planning programs to argue endlessly for one particular mapping package or another. While it is not an insignificant effort to design a planning system able to change from one mapping system to another, it is an essential ingredient to the successful joint planning system. Also, standard mission planning systems will not be able to perform LO tasks without significant redesign, time and money. Studies and prototypes built to convert non-LO systems to LO systems are painfully slow, inflexible and non-usable. In contrast, a system designed to do LO strike packages will be able to do non-LO strike packages seemingly without effort.

Mission commanders need automated methods to develop and disseminate strike package plans to LO strike fighter units [e.g. Joint Strike Fighter (JSF)] in a timely manner. Automated tools are needed to bring data from units to the commanders in near real time, display the data in a user specified format, deconflict the airspace to determine if the strike package is safe to fly, incorporate advanced LO tactics across the strike package, and electronically communicate any necessary changes to the units.

Effective automated tools would greatly improve integrated strike package planning and procedures, and would contribute substantially to the operational effectiveness and the survivability of LO strikes forces.

The goal of this topic is to demonstrate the use of emerging technologies in a basic distributed automated strike package and deconfliction planning system for LO vehicles that meets the needs of the Navy, Marines, and Air Force. This system should consist of integrating emerging technologies, and investigating and developing new and useful specific strike package algorithms. Passive Coherent Location (PCL) technology employed by an adversary will require new tactics and techniques to be performed by the strike force that could be best demonstrated, visualized and rehearsed on a LO planning system.

Current point-to-point deconfliction algorithms do not satisfy all of the requirements needed by LO strike package planners. LO vehicles rely on the preplanned missions to insure that they are not only out of harms way from enemy threats but also from contact with other air vehicles. The algorithm must take into account variances between the planned mission and the probable mission. These variances can be categorized as navigation error, altimeter error, early / late arrivals, variable aircraft speeds and winds, and tactical considerations. Another factor that must be included in the deconfliction of airspace is the need to, not only deconflict aircraft to aircraft, but also aircraft to weapon drops for any weapon in the airspace regardless of which aircraft deployed the weapon. As a part of the SBIR, a new deconfliction algorithm must be developed that would address these issues.

PHASE I: Conduct a proof of technological feasibility and assessment of operability and productivity of automated strike package planning systems. Prepare a systems definition document that details the strike package planning requirements for the JSF, and defines the automated system architecture and functionality needed to meet those requirements. The requirements for the system should meet the needs of the Joint Armed Services.

PHASE II: Develop a prototype, and finalize design and software system capabilities. Demonstrate capability in conjunction with scheduled field exercises (e.g., FBE, LOE, JEFX).

PHASE III: Finalize system design, conduct full-scale demonstration. Cooperative arrangement/licensing to aircraft manufacturers (e.g., JSF prime contractor), U.S. Government, and coalition partners.

COMMERCIAL POTENTIAL: The technologies developed under this SBIR project would have application in areas of air traffic management, collision avoidance, and air traffic operations, specifically safety of flight areas.

REFERENCES:
1. Classified materials not available to interested small businesses prior to selection. Further information will be posted on www.jast.mil or http://navair.navy.mil when appropriate.

KEYWORDS: Strike Package Planning; Airspace Deconfliction and Visualization; Agent Based Distributed Computing Architectures; Low-Bandwidth Communications; Platform Independent Software; Passive Coherent Location

N01-182 TITLE: Advanced Modeling to Characterize Failure Progression Rates from the Incipient Stage to Component Failure

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter (JSF)

OBJECTIVE: Develop and demonstrate advanced modeling techniques and programs that can be used to accurately characterize aircraft systems component (and/or sub-component) failure progression rates. The failure progression rates are to be characterized from the earliest incipient fault stages, incrementally through the final component (and/or sub-component) failure stages.

DESCRIPTION: In order to fully enable the predictive part of the Prognostics and Health Management (PHM) concept, there has to be some adequate level of understanding of the failure progression rate of the components (and/or sub-components) being monitored. This level of understanding can be acquired through careful and expensive "seeded faults" to failure tests conducted in a controlled environment; or through developing a knowledge base from actual (but rarely captured) fleet failures. A third way of acquiring this understanding of component failure progression rates would be analytically through the use of advanced models. This effort will develop, demonstrate, and apply these advanced models in support of the predictive part of PHM.

PHASE I: Define and report on a strategy to develop an advanced modeling program to characterize aircraft system failure progression rates from the incipient fault stage to final component failure. Develop a prototype-modeling program and demonstrate the feasibility of its use on an aircraft mechanical system component failure progression time history using, for example, spalled engine bearings or cracked gear teeth.

PHASE II: Develop an advanced modeling program or programs to characterize failure progression rates for several aircraft mechanical-systems components. Apply this advanced program or programs to accurately characterize the component and/or sub-component incipient fault failure progress rates for these aircraft mechanical systems, their components, and sub-components. These applications could include: bearing wear damage, blade crack growth, hot section erosion, and various gas path degradations for gas turbine engines; and bearing wear damage, gear teeth cracks and wear degradation for transmissions. Demonstrate how the fault failure progression rates provided by these models for these aircraft systems can be used to accurately predict a component failure event and to enable prognostics of the useful life remaining at any point in time. Assess the application boundaries and limitations for these modeling techniques.

PHASE III: Develop and deliver a complete set of application modeling programs to be use on several aircraft systems. Integrate the failure progression rate results of these modeling programs with a comprehensive Prognostic and Health Management (PHM) system. Apply these modeling programs a new aircraft development program like the JSF.

COMMERCIAL POTENTIAL: These advanced models would be applicable to any mechanical machine application that was applying diagnostics, prognostics, and/or health management capabilities. This is particularly true any rotating machines used in aviation, power plants, etc. The results gained from applying these failure progression rate models to particular systems would provide a significant cross over benefit to other similar applications, commercial or military.

KEYWORDS: Diagnostics; Prognostics; Modeling; Failure Progression Rates; Prognostics And Health Management; Failure Prediction

N01-183 TITLE: High-Temperature/Lower Cost Appliqué Material

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: Joint Strike Fighter (JSF)

OBJECTIVE: Develop an appliqué for aircraft that can operate in a temperature range of –65°F to 350°F. The material costs shall be lower than the currently developed fluoropolymer film/pressure sensitive adhesive. The applique shall meet the performance requirements of TT-P-2756, MIL-P-23377, MIL-P-85582, MIL-PRF-85285, and AMS 3603.

DESCRIPTION: The appliqué materials consist of a pressure sensitive adhesive layer, and a polymeric film. These appliqué material systems are being developed to replace the topcoat on aircraft. Currently applique systems operate in the temperature range of –65oF to 250oF. The next generation of flight aircraft will have an operational temperature range of –65°F to 350°F.

PHASE I: Provide an initial development effort that combines nontoxic corrosion inhibitors with a binder system to produce a lower cost appliqué system for use on Navy aircraft. The appliqué must meet the current military and performance specifications as well as be compatible with existing materials. Conduct preliminary laboratory testing to demonstrate the feasibility. Additionally, the application of the proposed applique should not interfere with the logistical and operational requirements of the naval facility tasked to use the appliqué.

PHASE II: Further develop the appliqué to meet the objectives of the Phase I result. Conduct both laboratory testing and field-testing

PHASE III: Produce the appliqué demonstrated in the Phase II effort. The appliqué will be transitioned to the Fleet through specification modifications and revisions to aircraft weapons systems technical manuals. If further development and/or field-testing are required, aircraft program funding or demonstrate funds will be pursued.

COMMERCIAL POTENTIAL: The appliqué can be used on commercial aircraft as well as non-aerospace applications for both the government and private sector as a replacement for paint. This material would be directly transferable to ships.

REFERENCES:

1. SAE ASM 3603, Protective Film: Polyurethane
2. MIL-P-23377, Military Specification Primer Coatings: Epoxy, High Solids
3. MIL-PRF-85582, Military Specification Primer Coatings: Epoxy, Waterborne
4. MIL-PRF-85285, Performance Specification Coatings: Polyurethane, High-Solids
5. TT-P-2756, Polyurethane Coating: Self-Priming Topcoat, Low Volatile Organic Compounds

KEYWORDS: Appliqué; Film; Paintless; Topcoat; Non-Paint; Polymeric Film

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the second fiscal year (FY) 01 solicitation (FY01.2). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology". If you plan to employee NON-U.S. Citizens in the performance of a DARPA SBIR contract, please inform the Contracting Officer who is negotiating your contract. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission are included, followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

Please note that **1 original and 4 copies** of each proposal must be mailed or hand-carried. DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Phase I proposals **shall not exceed $99,000,** and may range from 6 to 8 months in duration. Phase I contracts can not be extended.
- DARPA Phase II proposals must be invited by the respective Phase I technical monitor (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.
- It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee. However, DARPA may choose to award a Firm Fixed Price Contract or an Other Transaction, on a case-by-case basis.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-352-9333 or internet: http://ccr.edi.disa.mil and www.ccr.dlsc.dla.mil.

The responsibility for implementing DARPA's SBIR Program rests in the Contracts Management Office. The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/CMO/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 526-4170
Home Page http://www.darpa.mil

SBIR proposals will be processed by the DARPA Contracts Management Office and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.
- **Successful offerors will be expected to begin work no later than 30 days after contract award.**
- For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

The DOD SBIR Program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications ANYTIME during the 6th month of the Phase I effort. The Fast Track Phase II proposal must be submitted no later than the last business day in the 7th month of the effort. **Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity during the interim period and Phase II.** If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding generally, will not exceed $40,000.

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a phase II company with additional Phase II SBIR funding, not to exceed $200K, if the company can match the additional SBIR funds with non-SBIR funds from DoD core-mission funds or the private sector; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

DARPA FY2001.2 Phase I SBIR
Checklist

1) Proposal Format

a. Cover Sheet (formerly referred to as Appendices A and B) **MUST** be submitted electronically (identify topic number) ______

b. Identification and Significance of Problem or Opportunity ______

c. Phase I Technical Objectives ______

d. Phase I Work Plan ______

e. Related Work ______

f. Relationship with Future Research and/or Development ______

g. Commercialization Strategy ______

h. Key Personnel, Resumes ______

i. Facilities/Equipment ______

j. Consultants ______

k. Prior, Current, or Pending Support ______

l. Cost Proposal (see Appendix C of this Solicitation). Ensure your cost proposal is signed. ______

m. Company Commercialization Report (formerly referred to as Appendix E) **MUST** be registered electronically and a signed hardcopy submitted with your proposal (register at http://www.dodsbir.net/companycomercialization) ______

2) Bindings

a. Staple proposals in upper left-hand corner. ______

b. **DO NOT** use a cover. ______

c. **DO NOT** use special bindings. ______

3) Page Limitation

a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______

b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______

c. Company Commercialization Report (formerly referred to as Appendix E) **IS NOT** included in the page count. ______

4) Submission Requirement for Each Proposal

a. Original proposal, including signed Cover Sheet (formerly referred to as Appendix A) _____

b. Four photocopies of original proposal, including signed Cover Sheet and Company Commercialization Report (formerly referred to as Appendices A, B and E) _____

INDEX OF DARPA FY2001.2 TOPICS

SUBJECT/WORD INDEX TO THE DARPA FY2001.2 TOPICS

DARPA 2001.2 TOPIC DESCRIPTIONS

DARPA SB012-001 TITLE: Spectral Cueing/Spatial Confirmation Targeting System

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment.

OBJECTIVE: Develop a common optic system that will allow the capability to perform wide field of view spectral cueing and narrow field of view spatial confirmation on military targets of interest. Spectral resolution should be on the order of 1nm in the visible.

DESCRIPTION: *Most* current Automatic Target Recognition (ATR) systems utilize panchromatic spatial imagery. Unfortunately, these systems require high resolution, i.e. many pixels on target (narrow field-of-view), and are susceptible to Camouflage, Concealment, and Deception (CC&D) techniques. Multi/Hyperspectral Imagery, on the other hand, requires much more effort to perform *effective* CC&D since the techniques must be robust across many spectral bands. Also, since spectral detection techniques do not require high spatial resolution, wide field of view searches are possible. Tunable filter systems are of particular interest since they possess the capability to collect data in spectral regions-of-interest rather than gathering massive amounts of unutilized data. Unfortunately, there is not a common optic system that can perform both tasks of spatial and spectral recognition. This effort will focus on a system that can perform wide field of view spectral anomaly detection and narrow field of view spatial confirmation.

PHASE I: Draft a paper design system with common fore-optics that allow: 1) Wide field-of-view with selective spectral tuning from 400-1200nm and spectral bands having less than 5nm bandwidth. 2) Narrow field-of-view that has the capability to pan, or search, within the wide field-of-view.

PHASE II: Fabricate and demonstrate the system designed in Phase 1.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR effort can be utilized in the commercial sector to monitor such areas as agricultural growth, geological formations, and water pollution.

KEYWORDS: Automatic Target Recognition, Multispectral, Hyperspectral, Imaging Spectroscopy, Remote Sensing.

REFERENCES:
1. Chavez, P.S., Jr., Sides, S.C., and J.A. Anderson. (1991) Comparison of three different methods to merge multiresolution and multispectral data: Landsat TM and SPOT panchromatic. PE & RS., v. 57 (3), 295-303.
2. Ehlers, M. (1991) Multi-sensor image fusion techniques in remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing., v. 46, .19-30.
3. Garguet-Duport, B., Girel, J., Chassery, J., and G. Pautou. (1996) The use of multiresolution analysis and wavelets transform for merging SPOT panchromatic and multispectral image data. PE & RS., v. 62 (9), 1057-1066.
4. D. G. Goodenough, D. Charlebois, S. Matwin, and M. Robson (1994) Automating Reuse of Software for Expert System Analysis of Remote Sensing Data IEEE Trans. on Geos. and Rem. Sens., 32:525-533.
5. Larsen, M. (1997) Crown modelling to find tree top positions in aerial photographs. International Airborne remote sensing Conference and Exhibition, Proceedings II-428-435.

DARPA SB012-002 TITLE: Robust, No Power MEMS Sensors

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment.

OBJECTIVE: To develop robust, no power, low cost MicroElectroMechanical Systems (MEMS) sensors for missile guidance and missile health monitoring applications.

DESCRIPTION: With increasing developments in MicroElectroMechanical Systems (MEMS), new sensing techniques and devices are emerging rapidly. However, three significant deterrents to military application of many of these devices exist: 1) the miniature size and, in some cases performance of the sensors, are nullified by the size and performance of the power supply for the MEMS sensing devices; 2) the fabrication of different sensors on a single substrate is often difficult or impossible due to the incompatibility of certain processes; or 3) the devices cannot withstand military environments (shock, vibration, humidity, temperature, etc.). There is significant technical risk in all of the above areas; however, the pay-off if successful makes it well worth the investment. The purpose of this topic is to identify and develop MEMS sensing technologies that address these issues. Techniques such as Rayleigh surface wave detection or resetting latch banks have the potential for providing good performance while providing robust, no power, low cost sensors which can sense a variety of parameters and be fabricated in a single device. A variety of sensors are needed, including inertial (gyroscopes and accelerometers), temperature, humidity, chemical/biological/ neurological agents, strain, shock, and barometric pressure and wind speed sensors. Proposals should address as many of these

sensor types as possible in accordance with each of the issues above. Award consideration will be based heavily upon the completeness of addressing the named concerns, the innovative nature of the technology proposed, the economical advantages of the device(s) proposed, the applicability of the devices to both military and commercial uses, and the performance specifications/expectations of the sensor(s).

PHASE I: Identify specific design and fabrication techniques for MEMS sensors that address the enhancement of two or more application issues. Develop a detailed approach and schedule and develop a design concept for integration of multiple sensor types. Analytically demonstrate the capability of the proposed technology(ies) that will provide robust, low-cost, no power MEMS sensing devices for military applications. Define theoretical limitations of, and any technological barriers to implementation of, your design (including such parameters as performance, size, reliability, cost, etc.). Quantify the advantages of your approach, and conduct proof-of-principle experiments to verify proposed techniques. Short-term performance goals for inertial sensors must achieve a bias of 30 °/hr, with a dynamic range of ± 2,000 °/sec, over a temperature range of 0°C to +50°C.

PHASE II: Validate your robust, no power MEMS sensors for military applications by fabricating and demonstrating a brass-board prototype(s) of a no power μ-sensor suite, μ-Inertial Measurement Unit and/or μ-sensor components. Teaming with industry, or academia foundries as necessary is encouraged. Confirm performance through laboratory testing and quantify performance specifications for the micro-devices. Component-only demonstrations must be substantiated with judicious examination of integration issues.

PHASE III DUAL USE APPLICATIONS: The dual use potential of the product(s) from this effort is phenomenal. Markets extend from numerous automotive, aeronautical and robotic applications to mining and oil-drilling applications to medical and food industry applications. Potential market sales of small, low-cost conformal environmental and inertial sensing devices are astronomical.

KEYWORDS: MEMS, Sensors, Inertial Measurement Units, Rayleigh Waves.

REFERENCES:

1. Department of Defense, "Microelectromechanical Systems: A DoD Dual Use Technology Industrial Assessment," December 1995.

2. Varadan, V. K. and Varadan, V. V., "Wireless Smart Conformal MEMS-Based Sensors for Aerospace Structures," American Institute of Aeronautics and Astronautics, AIAA-98-5244, 1998.

DARPA SB012-003 TITLE: New Approach to Wave Oriented Radio Propagation Modeling

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop a new wave-oriented approach to the simulation of terrestrial radio wave propagation in high bandwidth, high data rate channels, with greater physical accuracy, which can predict relevant channel parameters for end-to-end paths over a variety of terrain features and under different atmospheric conditions.

DESCRIPTION: The computation of radio wave propagation over terrain of military and commercial wireless interest requires the simulation of end-to-end electromagnetic propagation over a variety of terrain and manmade features: hills, mountains, relatively flat earth, water bodies, rural areas, and suburban and urban areas. Propagation paths into buildings and into and through foliage need to be considered. Path configurations of interest include ground-mobile-to-ground-mobile, tower-to-tower, tower-to-ground-mobile, air or satellite-to-ground-mobile, and air-to-air. Special cases such as propagation in tunnels also need to be modeled. Path parameters affecting high bandwidth, high data rate communication channels must be simulated accurately. Path loss, polarization effects, and multi-path effects, such as angle of arrival, path delay and delay spread, coherence lengths, and fading statistics are potentially critical parameters. Existing methods of modeling such propagation paths include ray tracing approaches and the approximate full wave Parabolic Equation Method. New propagation simulation approaches with greater physical accuracy and greater computational efficiency need to be developed. Such approaches should be oriented to wave field propagation, but allow the expedient transition between wave-like and ray tracing or asymptotic techniques. A suite of modeling EM engines should allow the selection of different levels of physical accuracy, with correspondingly different computation times. The model must be capable of calculating the effect of atmospheric conditions on the propagation. Interfaces must be provided for the major commercial and government terrain, urban, and foliage databases. The model must be capable of analyzing narrow band frequency waveforms and arbitrary ultra-wideband waveforms. The frequency range of interest is HF through 100 GHz.

PHASE I: Demonstrate an EM computational engine capable of predicting channel parameters in the limited case of hilly, rural terrain. Demonstrate a graphical user interface optimized for radio wave propagation and radio channel parameter prediction.

PHASE II: Demonstrate the full capability propagation code, capable of predicting the channel parameters noted above for end-to-end paths through a variety of terrain and manmade structures.

PHASE III: DUAL USE APPLICATIONS: The resulting propagation code will be used by commercial wireless companies and government and military activities to design wireless communications networks and to design or procure the communications

hardware. It will be used to test new network and systems concepts for both military and commercial applications and to evaluate the ability of communications to support new military warfighting concepts such as the Future Combat Systems. It will be used to develop and evaluate communications plans for specific military operational areas and emergency and disaster areas for government activities. It will be used for en-route tactical communication planning by military and government contingency elements. It will be used to inject realistic communications path characteristics in war gaming and training. The market is expected to be wireless communications companies, government communications contractors, military communications planning and training activities, and the consultants supporting these activities.

KEY WORDS: Radio Wave Propagation, Propagation Model.

REFERENCES: None are provided because doing so will lead candidate proposals toward the use of existing propagation models, rather than the desired innovation.

DARPA SB012-004 TITLE: Processing Techniques for Dynamic Sources

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The work will develop innovative processing techniques for multiple moving acoustic sources. The intent is to be able to suppress a field of moving acoustic interferers while simultaneously enhancing the signal from a weak source that is also moving. The objective is to obtain significant passive sonar gains by extending coherent integration times by robustly compensating for source/receiver motion. The goal is to obtain 10 dB better interference rejection and a 6 dB or more improvement in signal gain for passive sonar.

DESCRIPTION: One of the fundamental limitations of adaptive signal processing stems from the need to estimate source statistics. Standard techniques make stationarity assumptions that are demonstrably inappropriate for passive sonar. In shallow water, the expected acoustic environment will include many discrete interferers that have appreciable range and bearing rates. Standard processing techniques have a limited ability to suppress these interferers; weak signals of interest from sources that are also in motion are also difficult to enhance. The goal here will be to develop processing techniques that significantly improve processing performance in this situation. Motion compensation techniques have been developed for radar sensors, imagery (the MPEG standard), and are emerging in sonar, but complex propagation environments and the large number of sources complicate the sonar problem. Emerging techniques for motion compensation in sonar are focused on narrowband models; the goal here is to develop compensation techniques that may be applied to broadband source signals. There is substantial risk, as evidenced by the fact that there are as of yet no standard techniques for performing this function, and indeed it is unclear whether practical optimum techniques exist, especially for broadband passive sonar. Generally, adaptive signal processing involves adaptively computing beam patterns by applying variable complex gains (weights) to individual sensor outputs, then summing the results. The optimum adaptive weights require knowledge of the data covariance matrix. This matrix is usually unknown, and therefore, must be estimated. In a dynamic environment, the sources are temporally non-stationary, so the problem is not ergodic, and covariance estimates obtained by temporal smoothing are inherently mismatched. There have been two approaches to this problem. First, there are a host of techniques designed to more efficiently estimate the data covariance matrix. At some scale, the problem becomes quasi-stationary; the amount of mismatch due to source/interferer mismatch negligible, and optimum performance may be recovered. The issue for this approach is that coherent integration times are not extended, so coherent gain on the signal of interest is not improved, although interference may be adequately suppressed. The second approach is to incorporate models of the source/receiver dynamics directly in the problem formulation. This model-based approach has been much less explored. One such approach is to model the time-varying behavior of the covariance matrix and incorporate this into adaptive weight estimators. Regardless, issues associated with a dynamic signal, as opposed to dynamic interference, have not been thoroughly studied.

PHASE I: This phase will develop a feasibility concept and implement processing techniques that target source fields that are known to be in motion. A software implementation of the concept will be tested on simulated data.

PHASE II: The task in Phase II is to more completely develop and test the processing developed in Phase I. A software prototype should be developed and demonstrated on a sample data set.

PHASE III: A real-time software module suitable for production will be developed and tested at sea.

PHASE III DUAL USE APPLICATIONS: Candidate applications for the product of this SBIR range from medical ultrasonic diagnostics and therapy, marine biology/fisheries and non-invasive testing to military issues such as undersea sound navigation, threat detection, and weapons guidance.

KEYWORDS: Acoustics, Adaptive Signal Processing, Motion Compensation.

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DARPA SB012-005 TITLE: RF Polymers for Integrated Sensors

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative uses for radio frequency (RF) polymers with application to integrated RF sensor technologies that provide increased functionality to reduce physical size, power consumption, signal loss, weight, and cost for structurally integrated apertures.

DESCRIPTION: The research will explore revolutionary concepts and conduct feasibility demonstration efforts of RF sensors that employ RF polymers to provide a low cost manufacturing capability. The effort will examine advanced RF polymer materials and RF aperture concepts for use on affordable, structurally integrated apertures. The effort will consider ideas that lead to a working aperture demonstration at the end of Phase II. This includes multi-function/integrated aperture concepts. Also, the effort could focus on the RF polymer conductive, dielectric or magnetic properties that will dramatically improve the above type of integrated apertures for final demonstrations. Limited material coupons or hardware breadboards will be fabricated to verify modeling results required. Selection of the demonstration vehicles shall be based on the developed RF polymers suitability for a specific integrated aperture and the availability of suppliers transferring these technologies from a research to a production environment. This program shall be divided into two phases.

PHASE I: Phase I will be the concept exploration phase that includes the verification of the novel integrated aperture architectures that make best use of the advanced RF Polymers. Concept Validation and Verification.

PHASE II: Functional demonstration vehicles and design of potential products shall be completed, such as an RF Polymer with a magnetic property appropriate for use as part of a circulator in an integrated aperture. It is expected that fabrication capability of commercial and military RF Polymer products will be established by end of Phase II.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: Commercial applications include portable electronics, wearable electronics, space-based systems, automotive electronics, and RF tags.

KEYWORDS: RF Polymers, Integrated Apertures, RF on Flex.

REFERENCES:

1. AFOSR Polymer Workshop, Dr. Charles Lee, AFOSR, 7-8 Dec, Hyatt, Chicago, IL.

DARPA SB012-006 TITLE: Gun Launched Interceptors

KEY TECHNOLOGY AREA: Weapons (Conventional Weapons)

OBJECTIVE: Develop technologies to enable supersonic, highly maneuverable, gun launched, guided medium caliber projectiles. Leap-ahead improvements are sought for survivable actuation devices, innovative flight control, inertial measurements and data links.

DESCRIPTION: Dynamic engagement simulations have suggested that gun-based weapon systems utilizing guided hit-to-kill projectiles have a number of militarily significant applications. A new generation of gun launched projectiles compatible with 12-40 millimeter weapons may be possible using recent advances in actuation technologies (materials/microfluidics/thrusters/synthetic jets), flight hardened electronics and packaging for +100,000g setback accelerations and power sources. Advanced manufacturing processes and multi-layer fabrication techniques may make it possible to fabricate the fins or structure of the interceptor with embedded electronic or control components. Of particular interest are technologies which enable the development of interceptors with greater than 50g's of lateral acceleration and less than 20 millisecond time constants.

PHASE I: Develop a low fidelity, system-level concept employing gun launched, supersonic projectiles having an outer diameter less than or equal to 40 millimeters. Demonstrate through analysis, models or detailed simulations the feasibility of the projectile. Although the emphasis is on enabling technologies, the devices must correlate back to the constraints of the offerer-developed system level concept. The hypothetical system concept must predict a system accuracy of less than 1 meter at 3000 meters downrange, be capable of exceeding 50 g's of controlled lateral acceleration within 300 meters of barrel exit, survive over 100,000 g's of firing setback and possess a minimum terminal velocity of 1000 meters per second at 3000 meters while carrying approximately 750 grams of payload. The design must then focus on one or more of the specific component technologies required by the system concept to launch the projectile, track targets, provide fire control and communicate with the projectile, etc. Continued development of the specified components will be the focus for Phase II. The technical and manufacturing risks associated with the concept must be identified in this phase and a detailed risk reduction plan for follow-on development must be presented.

PHASE II: Design, fabricate and demonstrate the performance of critical components needed to achieve the required performance levels or a complete projectile. Performance demonstrations will strive to utilize and demonstrate prototypes that are consistent with the volume and mass requirements of the offerer-developed system concept. Teaming with munitions-related industrial partners who are funding relevant internal R&D efforts is encouraged. Collaboration with munitions-related partners within government labs (at no cost to the SBIR program) is encouraged as a means to; 1) understand the launch and flight environments, 2) gain access to wind tunnels, air guns or other valuable development tools, 3) leverage advanced technologies developed under previous DoD-sponsored programs, and 4) facilitate commercialization/Phase III opportunities.

PHASE III DUAL USE APPLICATIONS: The technologies for supersonic control, drag reduction, inertial sensors, projectile communications and power can be used as a basis to design civilian projectiles for law enforcement applications and aerodynamic flight bodies for the civil and military aircraft industry.

KEYWORDS: Guided Projectiles, Micro-Fluidics, Controllable Drag, Inertial Sensors, Communications, Tracking, Fire Control, Supersonic Flight Control, High-G Maneuvers, Hit-to-Kill Lethality, Anti-Ship Cruise Missiles, Man Portable Air Defense Systems, Embedded Electronics, Structurally Integrated Devices, Smart Materials, Wind Tunnels, High-G Launch Setback.

DARPA SB012-007 TITLE: Multi-Modal Command Interaction

KEY TECHNOLOGY AREA: Human Systems

OBJECTIVE: Develop multimode command interaction technology integrating speaking and sketching protocols with maps; these innovative interaction techniques must work in harmony with current command methods, significantly improving overall performance.

DESCRIPTION: Computer systems and digital information in command posts often go unused or are used in tandem with paper-based systems because operators trust the paper-based system to a greater degree. This lack of confidence in digital systems can largely be attributed to difficult-to-learn and difficult-to-use systems, or to the fact that systems go down if you lose power. The overall goal of this research and development effort is to develop and test innovative new forms of multimodal human-computer interaction in command posts with a focus on improving overall confidence and performance. Key factors that must be evaluated relative to performance are productivity gains, ease of training, fewer errors, flexible collaboration, and less susceptibility to power and communications failures. In addition success will mean that the command post staff has significant confidence in the digital system and the specific user interface and interaction methods. Special emphasis must be given to multimodal interfaces that allow users to speak and draw to maps in order to provide normal modes of interaction for operators.

PHASE I: Develop an architecture for multimodal interaction with emphasis on combining speech and sketching on maps. Perform initial implementation experiments that provide evidence that the approach can be applied to map-based command post tasks operating in diverse hardware platforms and form factors, including wearable, wall-sized and paper-based systems. Develop a set of metrics and an experimental paradigm for demonstrating the strengths and weaknesses of the technology.

PHASE II: Develop and conduct experiments with a collaborative system based on the architecture from Phase I, which supports multimodal interaction with map-based systems. The system should employ voice and sketching technologies, accept military symbology found in Army and Marine Corps field manuals, and should operate with a wide range of devices including: Personal Digital Assistants (PDAs), tablets, laptops, workstations, paper maps, and wall-sized systems. The system should be usable by inexperienced military personnel, as well as by expert military users, with a minimum of training. The system should be evaluated in US Army or US Marine Corps exercises according to the experimental paradigm established in Phase I.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in the interfaces for a number of commercial technologies, including PDAs, cell-phones, as well as desktop and pen-based computers. Applications that can utilize this technology include executive information systems, commercial command and control systems, and data-entry systems.

KEYWORDS: Multimodal Interaction, Integrated Speech and Sketching.

DARPA SB012-008 TITLE: Genetically Engineered Biofilms

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: To determine the efficacy of genetically engineering biofilms for the detection of bacteriological warfare/chemical warfare (BW/CW) hazards and the potential for immediate warning and intervention at the site of the event.

DESCRIPTION: Biofilms are common in the environment and represent a unique non- vegetative state of microbial existence. In this state, many microbes exists in a lamellar protein matrix with greatly expanded metabolic and functional characteristics including the natural ability to sense other organisms via built-in signal transduction pathways. Common occurrences of biofilms include dental plaque, fouled ship hulls and cooling systems, the protein matrix seen on indwelling catheters and the organic coating in most irrigation and plumbing systems. Their ubiquitous nature, hardiness, and potential for genetic engineering, makes them a promising candidate for exploring their use as broad surveillance devices for the presence of hazardous substances such as pathogens or environmental contaminants. A secondary application is in the potential to link detection and neutralization by the same genetically engineered biofilm.

PHASE I: Feasibility: Explore the ability of natural biofilms to sense environmental contaminants and pathogens. Genetically modify the physiology, biochemistry and structural features of biofilms to explore their possible use as simple detection systems; demonstrate safety of biofilm-based system.

PHASE II: Demonstration: Characterize biofilm systems for specific detection; link detection and activation or neutralization; selection of specific agents of interest; broaden application to chemical agents.

PHASE III DUAL USE APPLICATIONS: Genetically engineered biofilms which are capable of detecting environmental hazards such as biological or chemical agents and initiating a neutralization process would shorten the time between detection and the safety of an area, food or water source. Commercially, biofilms are relatively untapped and under utilized by both the medical and environmental scientists. Applications include early detection of exposure to disease, ecological contaminants and increased food safety.

KEYWORDS: Biofilm, Food Safety, Water Safety, Biological/Chemical Defense.

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DARPA SB012-009 TITLE: Autogenous Repair of High Performance Materials

KEY TECHNOLOGY AREA: Materials / Processes

OBJECTIVE: Establish practical technology for fail-safe use of highly stressed materials/components of military platforms by development of rapid means for their automatic and autogenous repair or amelioration of damage.

DESCRIPTION: All military platforms and weapons unavoidably contain inherent flaws in the materials of their construction. It is these flaws and other damage sites introduced while in service, which grow and ultimately lead to either sudden catastrophic failures or to less dramatic, but very costly and performance-limiting aging/wear-out failures. There is a need to avoid such failures for the sake of successful mission performance, safety and reduction of life cycle maintenance and repair costs. Current means for achieving this are expensive, take assets out of service for prolonged periods for maintenance and require retirement of parts based on statistical criteria. None of these deal with unanticipated conditions leading to failure while a system is in service. To avoid all of these limitations, methods and technologies are needed which cause materials to self-correct damage features and damage effects automatically while in service. Achievement of this goal for high performance materials requires innovations that can automatically and internally reinforce or repair them while in operation. Materials to be considered must be relevant to military systems and include metals, polymers and composites. Incorporation of capabilities into the microstructure of a material for its self-modification upon experiencing damage is to be emphasized. Modifications leading to self-repair or self-patching of a material must be automatically and locally triggered by in-service conditions/effects (e.g., damage features, failure precursors, intensity of mechanical response, heat generation, chemical reactions, etc.) Schemes that require external intervention when damage occurs, rather than those that are automatic and self-contained within a materials system are not included in this program. Any such automatic schemes must be capable of being effective rapidly enough to offer hope for avoidance of catastrophic failure. Proposers must address this response/effectiveness time explicitly for specific materials. In addition to self-healing

concepts, this program also includes self-triggered, self-reinforcement considerations leading to increased capabilities for damping, stiffening, deflection and vibration control which would provide resistance to damage from dynamic loads. There are many phenomena, which might be considered as the basis for self-repair/self-reinforcement of high performance engineering materials. Practicality of implementation of a specific modification mode should be a major consideration in proposals.

PHASE I: Demonstrate efficacy of phenomena and approaches proposed to achieve automatically-triggered self-repair or self-reinforcement of high performance materials, or bringing damage propagation to a halt, or reinforcing sites undergoing damaging influences and even the restoration of soundness to damaged specimens. Proposed approaches for self-healing and related effects should consider triggering phenomena, the self-contained character of a self-healing materials system, shelf life concerns and measurements of the extent of restoration of property levels for materials investigated. Laboratory specimens of selected materials with seeded, controlled damage features (or potential damage initiation sites) should be evaluated as demonstration of proof principle of any proposed concepts. Analyze rate at which triggering and self-repair can occur for the approach proposed.

PHASE II: Demonstrate integrity of self-repair/self-reinforced specimens by testing after their exposure, under mechanical loads to relevant environmental conditions. Analyze load-carrying capability of self-repaired/self-reinforced materials and functions of time and imposed stress. Demonstrate best approach on specimens damaged under simulated in-service conditions. Identify and evaluate most suitable non-distractive evaluation (NDE) method for evaluation of self-repaired/self-reinforced materials under practical (non-laboratory) conditions. Modify approach to self-repair/self reinforcement as needed. Document approach and test procedures.

PHASE III DUAL USE APPLICATIONS: Successful development will result in processes, methods and systems with multiple applications in military aircraft, ships, and other vehicles. Commercial applications can be found, among many others, in the aircraft and propulsion industries, heavy machinery, chemical and other plants, power generation systems, and civil structures which will be subjected to combined influences of mechanical stresses, cyclic loads, humid and harsh chemical environments and perhaps vibration and seismic loads.

KEYWORDS: Materials Failure, Fracture, Self-Repair, Fatigue, Damage Accumulation, Fail-Safe Operation, Reliability, Metals, Composites, Polymers, Crack Growth.

DARPA SB012-010 TITLE: Portable Lifts

KEY TECHNOLOGY AREA: Human Systems

OBJECTIVE: Development of a chemical-mechanical powered machine that would enable a small unit of soldiers to scale buildings quietly and quickly in the urban terrain.

DESCRIPTION: Military doctrine in the urban terrain recommends that buildings be cleared from the top down, allowing the adversary to escape rather than force a confrontation. Current tactics rely on folding ladders, which can be bulky and awkward to carry and assemble in battlefield conditions. Other more traditional approaches utilize grappling hooks and a soldiers climbing ability. Either approach leaves soldiers exposed for an extended period of time. The energy required for lifting a soldier is rather modest, i.e., the potential energy change is equivalent to a small amount of hydrocarbon fuel. The Carnot efficiency of engines, power transmissions, heat transfer, noise generation and engine controllers all contribute to the technical challenge and will ultimately limit the achievable performance of such a machine. Creating a reasonably efficient and power dense conversion device that is capable of creating 1-2 hp of mechanical work quietly will be a tremendous challenge. Designing and developing a man-portable lifting device places stringent constraints on mass and volume. Moreover, a device should not exceed 50 decibels of volume and probably be less than 40 dB for special operations. The device should be capable of lifting soldiers with fighting load (~ 100 kg) at a rate of approximately 1 meter per second. It should be compact, approaching and exceeding 1 kWatt per kilogram and be as efficient as possible to minimize the fuel weight and thermal signature. There are a variety of new approaches that can be developed for efficient and quiet operation of chemical-mechanical devices utilizing advances in smart materials, Micro Electro-Mechanical Systems (MEMS), modern controls, computational fluid dynamics (CFD) and materials technology to develop efficient, power dense, quiet, mesoscale power plants.

PHASE I: Design a power conversion device, providing analysis that proves the feasibility of the overall design. Critical subsystems or a complete system should be demonstrated.

PHASE II: Demonstrate the use of the system to carry the equivalent of a fire team of soldiers (e.g., 4) with fighting load, ~100 kg, up the side of a multiple story building.

PHASE III DUAL USE APPLICATIONS: This device would have a number of applications in power generation, the construction industry, law enforcement, fire fighting and rescue equipment. Power generation is always a concern for the military. A quiet, nearly silent small efficient power generation system could be developed from the power plant developed herein. The recent development of chemical-mechanical powered nail guns has given new capabilities to the construction industry. Developing other compact sources of power generation will enable other devices that could operate without being

tethered to power sources. Applications to rescue equipment such as the "jaws of life," could be created which are man-portable and are self-contained units, such devices might include powered jacks and cutting devices.

KEYWORDS: Chemo-Mechanical Power, Power Plant, Man-Portable.

DARPA SB012-011 TITLE: Use of Light Emitting Diodes (LED) in Pathogen Elimination, Wound Healing and Tissue Regeneration

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: To develop technology that ensures rapid elimination of skin or wound pathogens and accelerates wound healing in a sterile environment.

DESCRIPTION: Light emitting diodes (LED) are semiconductor devices that convert electricity to colored light in a very efficient fashion. The LED is currently used in the commercial market for applications such as brake lights, advertisement displays and stoplights. There has been very little research of their use in clinical medicine. However, because of the ability to control their wavelength exposure, low temperatures and broad-beam characteristics, LED's might be useful in military medicine. For example, a major risk to military personnel includes contaminated traumatic skin wounds. Recent evidence has shown that LED might make a significant contribution in several critical areas for protecting soldiers including the detection and/or elimination of bacteria and the acceleration of wound healing. This includes the use of LEDs for thermal, radiation and chemical burns. As compared to traditional suturing or lasers, LED induced wound closure and healing would be superior because the controlled coagulation, a painless procedure requiring no anesthesia, is a desirable alternative to conventional treatment of open wounds. In addition, it might be possible to use alternative wavelengths in conjunction with a light sensitive (chromophores) topical detergent to show a physician or medic that bacteria has been eliminated from the wound area prior to closure.

PHASE I: LEDs will be studied at various wavelengths to display a skin presence of pathogens and the elimination of bacterial agents. The effective depth of penetration of the LED treatment will be determined for cellular stimulation. Particular bacterial agents contain color sensitive chemicals such as chromophores that can be stimulated by LEDs to alert an exposed individual of a physical presence. The use of LED's for wound healing would also be studied.

PHASE II: The inactivation of bacterial pathogens will be determined at specific wavelengths. This will lead to a mechanism for determining wound cleanliness to begin the healing process. LEDs will be studied at various wavelengths to find the effective in vivo stimulation of tissue growth, factors such as keratinocyte growth factor, transforming growth factor and platelet derived growth factor.

PHASE III DUAL USE APPLICATIONS: The commercial application of LEDs includes newer products to be used in effective sterilization of contact surfaces in a medical treatment facility without any residual chemical by-products.

KEYWORDS: Light Emitting Diodes, Pathogens Identification, Wound Healing, Tissue Growth Factors, Vascular Regeneration, Tissue Regeneration.

DARPA SB012-012 TITLE: Electronic Market-Based Decision Support

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop electronic market-based methods and software for decision analysis, to aggregate information and opinions from groups of experts.

DESCRIPTION: The goal of this SBIR topic is to demonstrate market-based methods applied to analyses of interest to the DOD. Strategic decisions depend upon the accurate assessment of the likelihood of future events. This analysis often requires independent contributions by experts in a wide variety of fields, with the resulting difficulty of combining the various opinions into one assessment. Market-based techniques provide a tool for producing these assessments. Futures markets are used in the commercial world to mitigate risks involving the future prices of commodities. As a side effect, they can provide accurate predictions of those future prices, by aggregating the diverse knowledge and expertise of all market participants. Experimental futures markets have been successful in some non-financial contexts, such as election predictions. Typically, the market maker issues a basket of contracts covering a set of events that is mutually exclusive and exhaustive. (In the election context there would be one contract for each candidate, which pays off if the candidate wins.) Market participants trade the issued contracts freely, buying and selling individual contracts through an electronic market. When the outcome is known, the market maker pays off only the winning contracts; before the outcome is known, the prices reflect market opinion of the probability of each outcome. Benefits of market mechanisms like this for aggregating the judgment of experts include: incentives to make the best judgments; self-selection by the experts themselves of the best-informed market participants; and rapid reaction to events that occur during decision analysis. These may include analysis of the likelihood of events that motivate the Quadrennial Defense Review,

prediction of the timing and impact on national security of emerging technologies, analysis of the outcomes of advanced technology programs, or other future events of interest to the DOD.

PHASE I: Design one or more markets to predict events in a limited domain of interest to the DOD. This will include selection of a domain for assessment, identification of a group of knowledgeable market participants, design of an incentive system for experts in that domain, integration of hardware and software for market operations and management, and establishment of an electronic market among the participants.

PHASE II: Manage the markets established in Phase I until the outcomes are known, and analyze their performance. Evaluate the accuracy of market predictions against predictions of the same events by other institutions. Develop more general techniques and software for motivating market participants, trading, managing the market, and extracting information from market events. Prepare to establish markets in broader contexts.

PHASE III DUAL USE APPLICATIONS: Technology developed under this SBIR topic can be used in strategic analysis for business, technology prediction for engineering, and other analyses of decision outcomes. Techniques and software for extracting information from market events will be useful in commercial analysis of markets in products, services, commodities and financial instruments.

KEYWORDS: Decision Making, Electronic Markets.

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DARPA SB012-013 TITLE: Robot Beacon Module for Minimum-Resource Mapping and Navigation

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment (Phase I) and Information Systems Technology (Phase II)

OBJECTIVE: Develop a low-cost beacon transmitter/receiver module for robot localization. Triangulation of beacons mounted on individual robots will support a "minimum resource" approach to indoor navigation and mapping by identifying areas of free space and areas containing beacon-occluding obstacles.

DESCRIPTION: The creation of a large number of small inexpensive mobile robots to perform tasks has been motivated in part by the perceived "industry" of swarm systems such as ant or bee colonies. Research is still needed to achieve the simplicity of these systems in order to be cost effective. One approach to minimize resources is to eliminate the need for the detection or perception of objects by mounting on each robot a beacon module that includes an omni directional beacon (probably IR), and a beacon detection sensor that can simultaneously detect multiple beacons on other robots and measure the bearing of each to less than one degree. Beacon triangulation (combined with knowledge of some baseline distance) will allow the determination of the position of any robot (and any object next to it) relative to the others. Occlusion of a robot's beacon will indicate the presence of an intervening object, while lack of occlusion identifies a "ray" of free space. Parallels can be drawn to coastal piloting (in the use of landmarks and navigational aids), aviation navigation (from beacon to beacon), traditional pre-GPS surveying (networks of triangulation stations), as well as robotic navigation using artificial landmarks. Besides the beacon module, each robot will include basic mobility, crude odometry, and very simple and inexpensive contact or near-contact object/obstacle detection sensors, perhaps implemented as an array of whiskers. The focus of this topic is the development of a minimum cost high performance beacon module itself. A highly integrated module will incorporate the beacon transmitter (capable of software-controlled modulation) and a beacon detection sensor coaxially mounted in the same package, with optical elements that provide gain in the horizontal plane for both the transmitter and detector. Processing integrated with the annular photodetector focal plane array will allow the module to provide the robot's main processor with the beam width and integrated intensity of each detected beacon, to provide some measure of its distance and each detected beacon's bearing and rate of change of bearing, to support triangulation. In addition, several modes of communication could be encoded in the beacon modulation, including transmitter ID, signboard/pheromone display, and broadcast messaging, as well as traditional connection-oriented communications services.

PHASE I: Perform the required technology tradeoffs and develop first the conceptual design and then the detailed design for a highly integrated version of the beacon module. Through analysis, simulation, and/or subsystem bread-boarding, determine the target performance specifications for the module in terms of detection distance, bearing resolution, communications bit rate, power requirements, etc.

PHASE II: Design and fabricate an integrated detector/processing chip, realizable with standard complementary metal oxide semiconductor (CMOS) fabrication technology, as the core for the beacon module. In large quantities, the manufacturing cost of the complete module should be targeted for less than $10.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used in a distributed system of very simple robots capable of performing a useful real-world mission such as mapping the interior of a building overnight with a

swarm of possibly hundreds of cockroach-sized robots. This would provide rapid-response information to groups such as emergency first responders, security guards, and search and rescuers.

KEYWORDS: Distributed, Robots, Navigation, Mapping, Beacon.

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DARPA SB012-014 TITLE: Interaction with Experiences

KEY TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop, demonstrate and evaluate methods that enable people to query and communicate a captured record of shared human and robot experiences. The focus is on capturing experiences from what one hears and sees, as well as from associated sensor data and electronic communications. Specifically this work should transform experience into a meaningful and accessible digital information resource that can be used to augment the cognition of humans.

DESCRIPTION: Military futurists are envisioning battlefields where humans work at a distance to control events on the battlefield. A key technical challenge is to improve the cognitive memory and rehearsal abilities of operators. In fact, interaction with experiences where the human can interact with past experiences holds promise to increase the cognitive performance of humans. This improved performance must translate into improved readiness and survivability for the research to pay off for the military. A key technical challenge is to focus on improving cognitive performance so that one operator can effectively control and monitor multiple Knowbots to meet mission needs. Normally the cascading interruptions, or mounting demands from complex operations will overcome the attention capability of a human operator. However, there is evidence that this situation may be reduced with information technology that will augment the cognition capabilities of both the human operator and the distributed 'bots. Needed is information technology to provide efficient and effective means of integrating groups of non-human systems into battlefield operations. Such a capability may indeed redefine the nature of the battlefield, and ensure that a commander can influence events by forcing future adversaries to react to us. A specific concern is to enable human combatants be able to dynamically task and monitor a large and diverse set of active assets, particularly under the stresses of the battlefield. To investigate this question, this innovative research will extend the conceptual foundations of computer-human interfaces through exploring ways to augment methods of tasking, monitoring, and communicating. A key interest is development of experimental methods to evaluate adaptive trade-off strategies between humans and groups of non-human systems in the presence of limited attention and bandwidth resources.

PHASE I: Conduct a feasibility study focus on an innovative information processing technology that enables the capture and analysis of experiences, and then coordinates actions of distributed group activity using multiple synchronized

streams of incoming observations to produce an effective schedule. For example, one might use the setting of a medical crisis, with an associated emergency response team to construct a collective experience, and then develop a synchronized schedule for action. The feasibility study should also identify the critical issues use for evaluating performance gains due to augmented cognition factors.

PHASE II: Develop a prototype system for understanding experiences giving emphasis to methods and experiments used to evaluate and augment the cognitive capabilities of both the human operator and 'bots. The focus of the prototype should be on memory enhancement, perceptional off-load of cognition, and context tracking. Specifically measure and evaluate the effectiveness of enhanced memory of individuals gained from an intelligent assistant utilized to tag and store information automatically extracted from events and relationships.

PHASE III DUAL USE APPLICATIONS: This technology would enable systems development of (1) medical crisis response teams controlling semi-autonomous agents in disaster areas that are difficult to reach or cover large geographical areas; (2) law enforcement officials operating in dangerous urban areas to more effectively use remotely-operated systems; (3) automobile and aircraft manufacturers developing safer navigation and control systems; and (4) people with disabilities extending their capabilities to better interact with mechanical and digital prostheses.

KEYWORDS: Information Technology, Augmented Cognition, Human Systems Interface, Mixed Initiative Interaction, Control and Monitoring.

DARPA SB012-015 TITLE: <u>New Event Detection</u>

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Demonstrate technology able to detect new events and/or significant new information about known events from continually flowing streams of news, electronic correspondence, et cetera. Sources may include audio and text data.

DESCRIPTION: For many defense and intelligence applications, it would be extremely helpful to find out quickly when new events occur or when new information appears about known events. Traditional information retrieval and search engine technology can help people locate information that they know to look for, but cannot detect that something new has happened. DARPA-sponsored research in the area of Topic Detection and Tracking (TDT) has achieved good results on Tracking (finding more stories about a known event) but has not done so well on Detection, especially First Story Detection (finding the first reference to an unexpected new event) and New Information Detection (identifying the new information in a series of stories about an event). Innovative approaches are required to solve the latter two problems. Robust, accurate, general-purpose, language-independent approaches are desired. It is important to minimize both false alarm and miss rates, and it would help to have a way to trade off those errors. The technical risk is high, but there are many possible approaches, including a wide variety of statistical pattern matching, clustering, language modeling, and content understanding approaches. It may also be possible to exploit multiple data streams simultaneously to good effect. We hope to stimulate creative thinking to solve this important problem. Although we are seeking high accuracy and a general approach, even a partial solution could be quite valuable.

PHASE I: Develop, then evaluate through an appropriate test, a promising capability for new event detection using English language data. (TDT corpora and evaluation metrics may be used.)

PHASE II: Extend work to include additional sources and at least one foreign language. Enhance algorithm as necessary. Build a technology demonstration system. (Must work on flowing data rather than static corpora.)

PHASE III DUAL USE APPLICATIONS: New event detection technology would be very useful in a wide variety of business applications (to alert decision makers to threats and opportunities arising from economic developments and from actions by competitors and government agencies), news gathering operations (to determine what is newsworthy), trend analysis, e-mail filtering, and call-center monitoring. Health applications include the tracking of infectious disease outbreaks. Defense applications include message prioritization, force protection, and intelligence gathering.

KEYWORDS: Topic, Event, Language, Speech, Text, Alerting.

REFERENCES:
1. Wayne, C. Multilingual Topic Detection and Tracking: Successful Research Enabled by Corpora and Evaluation. Second International Conference on Language Resources and Evaluation, May 2000. Available at http://www.nist.gov/TDT/research_links/Wayne-LREC2000.ps
2. Allan, J. et al. First Story Detection in TDT is Hard. Ninth International Conference on Information and Knowledge Management, November 2000. Available at http://ciir.cs.umass.edu/pubfiles/ir-206.pdf.
3. Allan, J. et al. Topic-based Novelty Detection 1999 Summer Workshop at CLSP Final Report. August 1999. Available at http://www.clsp.jhu.edu/ws99/projects/tdt/final_report/report.pdf.

DARPA SB012-016 TITLE: Engineered Bio-Molecular Nanodevices

KEY TECHNOLOGY AREA: Chemical/Biological Defense and Nuclear; Sensors, Electronics and Battlespace Environment; Biomedical

OBJECTIVE: Development and demonstration of hybrid bio-molecular assemblies that operate as devices with controlled inputs and outputs. Input/Output (I/O) mechanisms may include electrical, optical, chemical, mechanical, thermal or magnetic phenomena.

DESCRIPTION: Ongoing leading edge nanotechnology research is enabling remarkable precision in observing, manipulating and controlling phenomena at the molecular scale. Cleverly engineered assemblies of organic and inorganic molecules are starting to function as nanodevices that have specific inputs and outputs. Biological systems show remarkable sensitivity, specificity and efficiency due to the selective evolution of molecular mechanisms over millions of years. It is anticipated that hybrid molecular assemblies involving bio-molecules would enable the exploitation of these unique aspects of biological systems while affording the control that is possible through nanotechnology. This would lead to 'smart' bio-molecular assemblies with new functionalities (e.g., nanosensors, nanopower generators, nanochemical factories, etc.) and significant advantages (over conventional engineering systems) in terms of size, power consumption, efficiency and ease of fabrication. The development of this technology will revolutionize sensing and detection, in-vivo diagnosis and drug delivery, repair of tissue/cell damage, integrated mechanical/electronic/chemical devices at the nanoscale, etc. This would also enable 'smart' large-scale integrated systems consisting of several millions of such devices that will enable automated adaptivity/reconfigurability, feedback control and compensation at the system scale. This topic seeks innovative ideas for designing, fabricating and demonstrating different kinds of novel bio-molecular assemblies that form transducing elements between chemical, electrical, optical and mechanical phenomena. These would typically result in many functions at the molecular scale such as chemically induced nanomechanical motion, optically/electrically induced chemical synthesis, chemically induced optical/electrical reporting mechanisms, etc. This topic emphasizes the ability to control and manipulate these functions at the molecular scale. Preference will be given to proposals that clearly identify target areas of impact and present a plan to transition research results to these applications.

PHASE I: Demonstrate feasibility of designing, fabricating and operating hybrid bio-molecular assemblies capable of performing mechanical/chemical/electrical/optical transducing functions at the molecular scale. Feasibility studies may include experimental demonstrations as well as modeling and simulation. Quantify performance metrics of the proposed device in terms of efficiency and power consumption. Phase I must demonstrate feasibility of control of the device at the molecular scale.

PHASE II: Demonstrate design, fabrication, operation and control of devices developed during Phase I. Fabrication methods may include top-down photolithographic methods as well as bottom-up self-assembly processes. Develop and demonstrate methodologies to enable large-scale integration of the devices analyzed in Phase I. Demonstrate performance, controllability and robustness of device/system during operation. Complete documentation of the data, test cases, test results and the demonstration studies must be delivered upon completion of the contract.

PHASE III DUAL USE APPLICATIONS: This effort will form the groundwork for the development of a new generation of nanodevices that will perform desired functions at the molecular scale, from altering molecular properties to enabling active dynamic control of large scale systems consisting of integrated nanodevices. These developments will have a revolutionary impact on almost every discipline, especially health care and medical treatment, sensing/diagnosis and actuation, micro and nanoscale power generation, materials with controlled molecular properties, molecular computing and information processing systems, etc.

KEYWORDS: Molecular Assemblies, Bio-Molecules, Molecular Engineering, Large Scale Integration, Self-Assembly.

REFERENCES:

1. **National Nanotechnology Initiative**, internal NSTC/CT/IWGN report, reviewed by the President's Committee on Advisors on Science and Technology (PCAST) Nanotechnology Panel (http://www.nsf.gov/nano/).

2. **Nanostructure Science and Technology** (NSTC report). R.W. Siegel, E. Hu, and M.C. Roco, eds. 1999. Worldwide study on status and trends; available on the Web: http://itri.loyola.edu/nano/IWGN.Worldwide.Study/, on CD-Rom from WTEC, and as hardcover publication from Kluwer Academic Publishers (1999).

3. **Nanotechnology Research Directions**: IWGN Workshop Report. M.C. Roco, R.S. Williams, and P. Alivisatos, eds. 1999, available on the Web: http://itri.loyola.edu/nano/IWGN.Research.Directions/

4. **Nanotechnology – Shaping the World Atom by Atom** (NSTC report). I. Amato. 1999. Brochure for the public (this report); available on the Web: http://itri.loyola.edu/nano/IWGN.Public.Brochure/.

5. **R&D Status and Trends in Nanoparticles, Nanostructured Materials, and Nanodevices in the United States** Proceedings published in January 1998, R.W. Siegel, E. Hu and M.C. Roco, eds., WTEC, on the Web: http://itri.loyola.edu/nano/US.Review/.

DARPA SB012-017 TITLE: Nanoimprint Tooling

KEY TECHNOLOGY AREAS: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop nanoimprint machines that are suitable for patterning structures with critical dimensions in the nanometer regime.

DESCRIPTION: Nanoimprint lithography (NIL) is becoming an important method for low-cost and high-throughput patterning of nanostructures. No imaging optics is needed so many of the limitations associated with projection optical lithography are eliminated. In NIL, patterns are formed directly in a thin deformable layer by pressing a master (stamp) into the layer. This is accomplished at elevated temperatures (up to 150 C) and pressures (up to 300 pounds per square inch (psi)). However, no commercial tools are currently suitable or available for NIL. For example, commercially available presses cannot achieve the large-area uniformity needed for NIL and are not suitable for operation in a clean room environment. Furthermore, current commercial presses have a cycling time that is orders of magnitude longer than that required for a reasonable throughput with NIL. To make NIL a real manufacturing technology, it is essential to develop presses with the appropriate characteristics.

PHASE I: Perform a design study of NIL tools that offer the needed large-area uniformity (>4", scalable to 8"), cycling time (<5 min, scalable to <2 min), imprint pressure (max 300 psi) and imprint temperature (max 150 C), with clean-room compatibility. Identify the key parameters and application areas for such tools. Perform key sub-system proof of principle demonstration.

PHASE II: Develop the NIL tool prototype(s) according to the design study in Phase-I. Build and test prototype, and refine the design. Perform application driven demonstration. Design and develop automatic control system.

PHASE III DUAL USE APPLICATION: The new NIL tools will enable the manufacturing of many key military and civilian high-performance nanodevices, which are currently too expensive to manufacture with conventional technology. These devices include high-frequency Metal Semiconductor Field-Effect Transistors (MESFETs), mass storage, optical filters, and other optical signal processing elements.

KEYWORDS: Sensors, Nanostructures, Imprint, Nanodevices.

REFERENCES:

1. Several papers describing NIL can be found in the Journal of Vacuum Science of Technology volumes B16(6), Nov/Dec 1998, and B17(6), Nov/Dec 1999.

DARPA SB012-018 TITLE: Virtual Ultrasound Transducer Control for Telemedicine, An Application of Flexible MEMS Arrays

KEY TECHNOLOGY AREA: Biomedical and Human Systems

OBJECTIVE: Develop a flexible substrate of transducer elements suitable for adaptive beam forming to serve as the foundation of a telemedical ultrasound system.

DESCRIPTION: Ultrasound is an extremely useful and prevalent medical diagnostic technique. The value of diagnostic ultrasound could be significantly extended with a carefully designed system to enable a centrally located medical expert to remotely evaluate patients in both civilian and military paramedical triage. Critical to the utility of a telemedical ultrasound system is the ability for the specialist to remotely manipulate a virtual transducer while evaluating the ultrasonic image. In echocardiography for example, the cardiologist requires subtle manipulation of both the placement and orientation of the ultrasonic transducer to effectively develop and interpret the diagnostic image. This remote manipulation could be accomplished with a two-dimensional transducer array applied to the patient's skin, which is capable of remote electronic beam steering. The specialist at the centralized location could manipulate a "virtual reality" pointing device which would transmit the required control signals to electronically steer the ultrasound beam, effectively creating a virtual transducer at the remote location. The critical technology required to implement a telemedical ultrasound system is a 2-D array of transducers on a flexible substrate integrated with a signal processing computer system capable of adaptive beamforming. A technician with limited specialized skills could apply the flexible substrate, or sheet of transducers to a patient in the general area for evaluation. Once the transducer array is applied to the patient a specialist at a remote location could transmit commands to the adaptive processor to remotely steer the ultrasonic array, simulating the physical manipulation of a traditional ultrasonic transducer array. In addition, it may be possible to achieve a significant improvement in image quality by the appropriate use of the full aperture of the adaptive array. Interactive manipulation of the transducer while viewing the diagnostic image in real-time is an integral component of diagnostic ultrasound. A preliminary demonstration of this technology might start with the replacement of the manually manipulated transducer of current systems with an advanced transducer array capable of virtual manipulation via remotely transmitted commands. This transducer array can incorporate MicroElectroMechanical Systems (MEMS) technology to achieve a flexible sheet form factor, which would allow it to create an ultrasonic image equivalent to the image acquired by a

traditional transducer in almost any position or orientation along the torso. The flexible nature of the transducer array will readily conform to the shape of the torso, and further will be able to move and flex as the torso moves, for example, during respiration. Algorithms and techniques will need to be developed in order to accomplish the required beamforming in this dynamic environment.

PHASE I: Develop a detailed performance requirement specification for both the transducer array and the processing system to achieve a sheet of electronically steerable transducers elements compatible with diagnostic ultrasound. Develop concepts and algorithms for achieving the adaptive beamforming in a dynamic environment.

PHASE II: Build and demonstrate a prototype system which at a minimum includes a flexible substrate of transducer elements and algorithms and a processing system capable of demonstrating adaptive beamforming in a dynamic environment compatible with diagnostic ultrasound.

PHASE III DUAL USE APPLICATIONS: This technology has military implications for distributing the expertise of well-trained personnel to the frontlines of conflict when needed. The commercial uses and benefits of this technology have the potential to surpass even those of the military. Once the principles of remote ultrasonic diagnostics have been demonstrated, the same thinking can extend to other remote diagnostics and even correction of human ailment.

KEYWORDS: Telemedicine, Ultrasound Systems, Beamforming Arrays, MEMS, Paramedical Triage, Echocardiography.

DARPA SB012-019 TITLE: Clutter-Limited, Collaborative Electromagnetic Sensors

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Demonstrate self-orienting and calibrating, low frequency (emphasis below 2 kilohertz), field-deployable electromagnetic sensors (B field and/or E field) that perform near or below atmospheric noise levels and are characterized as small (size and weight), low-power devices with supporting algorithms.

DESCRIPTION: Highly sensitive, low frequency electromagnetic sensors are needed for military applications addressing target location, planning, and movement. Desired sensor measurements include both total field and vector field components. These devices and supporting algorithms must be capable of performing at sensitivity levels near or below the natural (atmospheric) electromagnetic (EM) clutter background. Some low-power technologies are promising but still have sensitivities above the EM clutter background. Examples include magneto-resistive devices such as Spin-Dependent-Tunneling (SDT). Other sensors with adequate sensitivity such as Superconducting Quantum Interference Devices (SQUIDs) and conventional laser-pumped quantum devices continue to be quite large or to consume significant power for cooling. Responses are invited that are capable of supporting long-baseline (100's of meters) gradiometry, including self-orientation and calibration (at a minimum, relative calibration among spatially separated sensors) – whether by exploiting the background, by absolute, independent calibration, or exploitation of a common reference. Critical noise performance elements to be addressed include both self-noise and sensor-placement noise, such as coupling to real-world vibrations (seismic, acoustics). In addition, the sensors should address some or all of the following performance goals: (A) Modest size: individual receivers should have maximum dimension of 10 cm or less; (B) Low power: less than milliwatt of average power per receiver; (C) Broad band: 10 Hertz to 2000 Hertz (although higher frequencies – up to 30 KHz are of interest); (D) High sensitivity: for B field, noise equivalent performance less than 5 picoTesla/root Hz in the 10 Hz to 300 Hz frequency range, noise equivalent performance less than 0.5 picoTesla/root Hz in the 300 Hz to 2000 Hz frequency range; noise equivalent performance of electric-field sensors should be below the clutter background. (E) High dynamic range: receiver linearity and dynamic range (not digitizer) - capable of a linear output over a range of 80 dB; (F) Robust outdoor performance: insensitive to likely levels of insitu vibrations (wind noise, seismic noise) or to significant changes in ambient temperature (-20 degrees to 50 degrees C) and humidity variations (5 -100% relative), and insensitive to shock (less than 100 g's). The characteristics presented above do not include the power source (e.g. batteries), digitizing electronics, local processing or communications. Those responding may expand beyond the above listed desired capabilities or justify a limited-performance concept.

PHASE I: Develop self-calibrating, self orientating concepts to measure magnetic field and/or electric field meeting or approaching significant elements of the above goals. Identify critical technology elements and conduct laboratory-type measurements to confirm the soundness of the highest risk elements for prototype development. Present a top-level design concept.

PHASE II: Design, fabricate, and demonstrate sensors and supporting algorithms (self-orienting, self-calibrating) to measure magnetic field and/or electric field in robust outdoor environments. Demonstrate long-baseline (100's of meters) gradiometry, including independent, relative self-orientation and calibration. Demonstrate small size, low power, low weight, impact tolerant packaging.

PHASE III DUAL USE APPLICATIONS: Low frequency electromagnetic sensors have both military and commercial applications in detecting and monitoring electrical machinery, vehicular traffic, and personnel movement. Commercial applications include law enforcement, security surveillance, geophysical exploration, and planetary exploration.

KEYWORDS: Magnetic Field, Electric Field, Sensor, Low Frequency.

REFERENCES:
1. Lenz, J. E.; "A review of Magnetic Sensors", Proceedings of the IEEE, vol. 78, p. 973-989, 1990.
2. ITU, report PI. 372-6, "Radio Noise", circa 1994.
3. Lanzerotti, L. and Maclennan, C. "Background Magnetic Spectra: 10^-5 to 10^5 Hz", Geophysical Research Letters, vol. 17, no. 10, 1990.

DARPA SB012-020 TITLE: Inlet Injection of Oxidizer for Turbojet Acceleration

KEY TECHNOLOGY AREA: Space Platforms, Air Platforms, Weapons

OBJECTIVE: Develop, modify and test a conventional afterburning turbojet engine to operate to higher Mach numbers, to higher altitudes and with higher thrust by injecting oxidizer mass into its inlet. Using older, surplus military afterburning turbojet engines, this can be done within the scope of an SBIR Phase I and II.

DESCRIPTION: Despite numerous focused efforts at low-cost solutions, the high cost of access-to-space remains a stressing mission constraint in developing the space environment. One approach that has received little attention to date concerns the use of compressor pre-cooling resulting from inlet oxidizer mass injection into an afterburning turbojet. An afterburning turbojet engine modified in this way could be the propulsion for the first stage of a reusable launch system. In short, compressor pre-cooling resulting from inlet oxidizer mass injection will allow a turbojet engine to fly to higher Mach numbers, have higher thrust, and operate to higher altitudes. Turbojet cycles have been previously investigated for use as the first stage engine in both single-stage-to-orbit and two-stage-to-orbit systems. These mission studies have demonstrated that the high specific impulse offered by turbojet engines nearly negates the disadvantage of accelerating the turbo machinery to high speed during the portion of a mission where the turbine engine is not operating. When consideration of aborts options and powered landings are considered, the turbojet offers many benefits compared to alternate concepts. One of the main issues associated with operating a turbojet at high Mach number concerns the excessive compressor outlet temperature (T3) that typically results. Similar problems with T3 occur under warm day conditions at takeoff and climb with older turbojet engines. Pre-cooling with water injection for take-off and climb performance under warm day conditions was very common in the early history of turbojet operations. Water injection not only provided pre-cooling of the compressor flow, but also added mass to the flow that resulted in an increase in thrust. Mass injection of cryogenic oxidizer, or expansion of compressed oxidizer, could be used in existing turbojets in the same way as water injection was used in the past for pre-cooling to high Mach Numbers and for enhancement of thrust. The use of an oxidizer for pre-cooling also has the advantage of allowing the turbojet combustor to remain in operation to higher altitude. The use of cryogenic propellants could potentially allow the staging Mach number to be increased to Mach 6. The higher staging Mach number would also allow the used of a more optimal rocket. A turbojet engine that is modified to have inlet pre-cooling can be operated at low altitude and Mach number conventionally, with pre-cooling progressively increased with rising Mach number and altitude, where humidity will be low (avoiding icing effects). As the Mach number and altitude increases the injection of cryogenic propellant can be added to both pre-cool the compressor, increase engine thrust, and to keep the combustor lit. As more mass is added to the flow, more fuel can be added to the combustor, again increasing thrust. Also the addition of oxidizer to the flow will result in more oxygen in the afterburner. This will allow the engine to produce yet more thrust in the afterburner section. Although several more complex engine cycles have been proposed, this approach has the advantage of directly utilizing the significant technical and economic investment made in existing turbojet engines for the last sixty years. Assuming the reusable first stage of a launch vehicle using this technology is basically a high-speed airplane with a modified engine, this approach allows the launch vehicle's concept of operations to evolve from familiar aircraft type operations.

PHASE I: Perform engine cycle analysis modeling engine behavior with various candidate oxidizer injection fluids and schemes. Demonstrate basic feasibility on a small turbojet engine. An approach that avoids modifications to existing engine bearings, seals and hot sections while providing reliable and smooth operation is the primary challenge.

PHASE II: Modify an existing afterburning turbojet engine and characterize performance.

PHASE III DUAL USE APPLICATIONS: An accelerator afterburning turbojet engine that is capable of flight to high Mach number and high altitude has significant commercial and military markets in space launch applications. This technology can also be applied to high-speed, long-range, rapid response missiles. Super-sonic business jets also have the need to accelerate quickly to their cruise altitude and speed. This technology could enable the engines of these vehicles to be optimized for cruise, while still have the capability to climb and accelerate with the assistance of this technology.

KEYWORDS: Afterburning Turbojet Engines, Pre-Cooling, Mass Injection, Air Breathing Propulsion, Reusable Launch Vehicle.

REFERENCES:
1. Henneberry, H.M, Snyder, C.A., "Analysis of Gas Turbine Engines Using Water and Oxygen Injection to Achieve High Mach Numbers and High Thrust," NASA TM-106270, July 1993.

2. Burkardt, L., Norris, R., "The Design and evolution of the Beta Two-Stage-To-Orbit Horizontal Takeoff and Landing Launch System," AIAA 92-5080, Dec. 1992.
3. Trout, A.M., "Theoretical Turbojet Thrust Augmentation by Evaporation of Water During Compression as Determined by use of Mollier Diagrams," NASA TN 2104, June 1950.

UNITED STATES SPECIAL OPERATIONS COMMAND

Proposal Submission

The United States Operations Command's (USSOCOM) mission includes developing and acquiring unique special operations forces (SOF) equipment, material, supplies and services. Desired SOF operational characteristics for systems, equipment and supplies include: lightweight and micro-sized; reduced signature/low observable; built-in survivability; modular, rugged, reliable, maintainable and simplistic; operable in extreme temperature environments; water depth and atmosphere pressure proof; transportable by aircraft, ship and submarine, and deployable by airdrop; LLPI/LPD jam resistant C3I, electronic warfare capable of disruption and deception; near real-time surveillance, intelligence and mission planning; highly lethal and destructive; low energy/power requirements; and compatible with conventional force systems.

USSOCOM is seeking small businesses with a strong research and development capability and an understanding of the SOF operational characteristics. The topics represent a portion of the problems encountered by SOF in fulfilling its mission.

Inquires of a general nature or questions concerning the administration of the SBIR program should be addressed to:

United States Special Operations Command
Attn: SOAL-KS/Ms. Karen L. Pera
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621
Email: perak@socom.mil

USSOCOM has identified technical topics for the FY '01.2 solicitation and proposals will only be accepted for those topics. The USSOCOM Program Executive Officers (PEOs) responsible for the research and development in these specific areas initiated the topics. The same office is responsible for the technical evaluation of the proposals. Proposal evaluation factors are listed below. Each proposal must address each factor in order to be considered for an award. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

The maximum amount of SBIR funding for a USSOCOM Phase I award is $100,000 and the maximum time frame for a Phase I is 6 months. Phase I proposals less than 6 months and/or less than $100,000 and are encouraged where low risk technologies are being proposed. SOCOM Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months (option) of incremental funding should also be approximately $375,000. Phase II proposals less than 24 months and/or less than $750,000 are encouraged. The maximum amount of SBIR funding for a USSOCOM Phase II award is $750,000 and the maximum time frame for a Phase II is 24 months. Proposals should be based on realistic cost and time estimates, not on the maximum time (months) and dollars. The cost of the project is based on the overall amount of hours spent to accomplish the work required and the overall term of the project should also be based on the same effort. In preparing their proposals and plan of objectives and milestones, firms should consider that workload and operational tempo precludes extensive access to government and military personnel beyond established periodic reviews.

Evaluation Criteria – Phase I & II

1) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

2) The qualifications of the proposed principal/key investigators supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

3) The potential for commercial (Government of private sector) application and the benefits expected to accrue from this commercialization.

Selection of proposals for funding is based upon technical merit and the evaluation criteria included in the solicitation. As funding is limited, USSOCOM will select and fund only those proposals considered to be superior in overall technical quality and most critical. USSOCOM may fund more than one proposal in a specific topic area if the technical quality of the proposals are deemed superior, or it may fund no proposals in a topic area.

Electronic Submission Instructions

All proposal information must be received electronically via the DoD SBIR/STTR Submission site. To submit, proceed to http://www.dodsbir.net/submission. Once your firm has been registered, they may prepare (and edit) Company Commercialization Report Data, prepare (and edit) Proposal Cover Sheets(s) (formerly referred to as Appendix A and B), complete the Cost Proposal form, and upload corresponding Technical Proposal(s). Electronic proposals will be submitted by 3:00PM EST on August 15, 2001. The submission, exclusive of the Company Commercialization Report, may not exceed 25 pages.

Paper copies will not be considered. A complete electronic submission is required for proposal evaluation. Proposal evaluation will be accomplished via a secure web site. Please call your nearest Electronic Commerce Regional Center for assistance in uploading proposals. Please note that there have been problems in the past with AOL uploads due to their system, therefore strongly suggest an alternate internet service provider (ISP) for files larger than 5MB. It is strongly suggested you submit your proposal 3-5 days prior to closing date to ensure complete submission. Proposers are responsible for complete submission.

Refer to the on-line help area of the DoD SBIR/STTR Submission site for questions, troubleshooting, etc. For further assistance, contact the help desk at SBIRHELPDESK@pbcinc.com or 1-866-216-4095.

USSOCOM offers information on the Internet about its SBIR program at http://www.socom.mil and http://www.acq.osd.mil/sadbu/sbir.

Electronic Technical Proposal Upload

The term "Technical Proposal" refers to the part of the submission as described in Section 3 of the Solicitation. WordPerfect, Text, and MS Word are the preferred formats for proposal submissions. You are encouraged, but not required, to embed graphics within the document. When including images, care should be taken to ensure images are not of excessive size. A resolution of 200 dpi or below is requested for all embedded images. Please use standard fonts in order to prevent conversion difficulties. An overall file size of 5MB or less is recommended for each electronic proposal submission.

You will receive a confirmation page via the submission site once the proposal has been uploaded. The upload will be available for viewing on the DoD SBIR/STTR Submission site within 24 hours. It is within your best interest to review the upload to ensure the server received the complete file. Questions or problems should be directed to the help desk as mentioned above.

You are responsible for performing a virus check on each proposal to be uploaded electronically. The detection of a virus on any submitted electronic technical proposal may be cause for the rejection of the proposal. USSOCOM will not accept e-mail submissions. You should contact your Internet Service Providers to if you have questions concerning the provider's file size transmission allowance.

USSOCOM
FY 2001.2 SBIR TOPIC INDEX

SOCOM 01-005 TITLE: Remote Runway Survey System to Measure Soil Type, Load Bearing Capacity, Slope and Grades

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Design and build a lightweight, portable, runway survey system that can be deployed remotely, function unattended, and is capable of transmitting data to a remote operations center. The purpose is to determine if a segment of property is suitable for use as an aircraft runway or military drop zone.

DESCRIPTION: Recent advances in imbedded computers, direct and remote sensing devices, video cameras, remote soil samplers, robotics, communications and related technologies make remote soil sampling and dimensions measurement for assault zone suitability possible. Assault zones include landing zones for fixed and rotary-wing aircraft and drop zones for troops and equipment. The Air Force surveys these areas on a regular basis to physically measure assault zone characteristics: physical dimensions, magnetic orientation, coordinates, obstacles, elevation, weight-bearing capacity of the soil (California Bearing Ratio/Airfield Index), soil composition, terminal navigation aid suitability, etc. Air Force Special Tactics operators need to take precise measurements compromising their safety or otherwise drawing attention to their activity in non-permissive or denied areas. Of particular importance is establishing the strength of the soil, in terms of the Airfield Index (AI), to correlate aircraft performance to calculated AIs. Because soils vary in type and condition from site to site, and by season, there is a direct relationship between AI, aircraft performance, and operational capability. For this reason, site measurements must be accurate, and repeated as soil conditions change. Physical measurements for assault zones must be taken without detection. The weight-bearing capacity of the soil along and throughout the entire site must be measured without physically disturbing the site. Along with load bearing measurements, measurements of width, length, elevation, slope gradients, and lateral and longitudinal obstacle clearances of the runway or drop zone, correlated with ground coordinates, are required. True magnetic bearing must be provided, and an evaluation of best siting locations for navigation aids, autonomously or from previously entered data must be made. Measurements for drop zones do not require extensive soil load bearing measurements. All this data must be stored and transmitted to a remote site.

Sensors/capabilities that apply include:
* Space Based Imagery as a first quantifier of where suitable runways and drop zones might be placed. Applicable research includes:
* Ground Penetrating Radar that might be useful in measuring soil density and calculating load bearing qualities.
* Dynamic Cone Penetrometer
* Push probe sensors
* Inclinometer and GPS
* Imagery sensor
* Still frame or video sensor to beam back pictures of obstacles

PHASE I: A lightweight low-cost, perhaps disposable, solution to providing the described capabilities is required. Define and design a system with the capability to traverse an assault zone, measure soil characteristics, calculate load bearing capacity for large military aircraft, and measure the physical dimensions of the assault zone, including property slope and magnetic orientation. The design shall include a communications capability compatible with a military approved frequency and that uses standard modulation.

PHASE II: Prototype the system and demonstrate its capability to meet the requirement in an operationally realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where load bearing capabilities of soil and surface slope are important. Airport, road, and building construction projects could benefit immediately from this capability.

REFERENCES:

1. White Paper, Identifying Unprepared Landing Sites for Advanced Theater Transport Aircraft (and Terrain Trafficability for Military Vehicles), Mr. Dave Manley, The Boeing Company, Advanced Theater Transport Program Manager, 2401 E. Wardlow Road, Long Beach, CA 90807-5308, (562) 982-2156

2. Opportune Landing Sites, Bowling Green State University, Geology Department, Bowling Green, OH, 43403

3. Micropower Impulse Radar, MIR Program Office, c/o JoAnn Frost, Lawrence Livermore National Laboratory, P.O. Box 808 L-290, Livermore, CA 94551, Telephone: (925) 423-1077, Fax: (925) 422-3358, E-mail: frost4@llnl.gov

4. Automated Dynamic Cone Penetrometer, Vertek Manufacturing, RR1, Box 120A, Waterman Road, South Royalton VT 05068. (800) 693-6315

5. Air Force Civil Engineer Support Agency, Tyndall AFB, FL, http://www.afcesa.af.mil/

6. Push Probe, EPA SBIR Contract Number: 68D00271, Integrated Downhole Gas Chromatograph and Automated Sampler for Direct Push, Dr. Michael Dvorak, Dakota Technologies, Inc., 2201-A 12th Street, North Fargo, ND, 58102-1803. Telephone Number: (701) 237-4908

7. Micro Push Probes: NASA has several programs, but specific references are unknown.

8. Remote soil sampling vehicles: NASA, Rocky 7 and SOJOURNER, http://mpfwww.arc.nasa.gov/tasks/scirover/factsheet/homepage.html
a) American Society of Testing and Materials (ASTM) D1633. Compression Strength of Molded Soils Cementing Cylinders. 1990. b) FM 5-430-00-2/AFP 93-4. Volume II. Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations: Airfield and Heliport Design.

9. American Society of Testing and Materials (ASTM) D1633. Compression Strength of Molded Soils Cementing Cylinders. 1990. b) FM 5-430-00-2/AFP 93-4. Volume II. Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations: Airfield and Heliport Design.

KEYWORDS: Sensors, robotics, remote measurement, communications, vision system, pattern analysis

SOCOM 01-006 TITLE: SOF Tactical Information Assistant

TECHNOLOGY AREAS: Information Systems

Objective: The goal of this program is to enhance personal and/or team performance through the use of tactical information assistants. The approach is to seek innovative technology ideas that offer significant added value to current practice and that can be embedded into portable tactical systems that are safe, reliable and economical. This SBIR will design and build rugged, inexpensive portable tactical display units for deployed SOF personnel.

The SOF Tactical Information Display (STID) could be adapted from commercial products. Two different types are desired; one head-mounted, the other wrist-mounted. These tactical information displays will be used to provide graphical and alphanumerical information transmitted from the PDA or any computer using wireless methods. STIDs will be small, portable, electronic displays that provide individual users or teams with application specific information to enhance their mission success. Predictions from commercial electronic articles (Electronics Design, Oct 16, 2000) indicate that in ten years head or wrist mounted displays will be standard throughout society. There is a strong emphasis on the use of displays (direct view or head mounted) to present information in a visual form.

As indicated above, two versions of the STID are desired; one head-mounted, the other wrist-mounted. These will provide the soldier with hands free information. Both will use low power wireless technology (such as "Bluetooth") to receive video signals from a SOF operator's computer or the PDA described in this SBIR. Both STIDs will basically be a "remote" display, similar to a computer monitor.

The head mounted STID will take the form of eyeglasses and/or a helmet mounted display. It will have the following requirements: SVGA resolution, 32 degree viewing angle, 32k colors, 60 frames/sec refresh rate, 1W power consumption, contain a rechargeable battery that will last a minimum of 6 hours, and have an external DC input (to run with an external power source and/or charge the internal battery). Objectives are XVGA resolution, less than .5W power consumption, and a rechargeable battery that will last 12 hours.

The wrist-mounted STID will be a high resolution, low power display. The displays will have adjustable luminance, from off (dark) to bright enough to be seen in bright sunlight. It will have a requirement of SVGA resolution, 1W power consumption, 32k colors, contain a rechargeable battery that will last a minimum of 6 hours, and have an external DC input (to run with an external power source and/or charge the internal battery). Objectives are XVGA resolution, less than .5W power consumption, and a rechargeable battery that will last 12 hours.

A wireless transmitter to communicate from the computer to the STID will be designed and built and packaged into a

very small box that would connect directly to a port of the computer or PDA (e.g. VGA port). Software will be written if needed to allow the operator to quickly configure what data will be passed to his STID. The transmitter and STID will not have to communicate from a distance greater than 10 feet; will be low power and not be detectable at a distance of more than 50 feet.

The STIDs must be able to survive and correctly operate after being submersed at depths of two (2) atmospheres for three (3) hours, parachuted from altitudes of up to 20,000 feet, transported by air at altitudes up to 40,000 feet, and exposed to temperature extremes -20* to +70* C for extended periods.

PHASE I: Perform a study to evaluate current commercial display technologies, head-mounted and wrist-mounted display configurations, and software that could fulfill the above requirements. The study should emphasize the best display at the lowest power consumption. Develop design for Phase II.

PHASE II: Design and build, or modify existing COTS hardware/software to perform and/or support the desired functions. Build two of each head-mounted and wrist-mounted STIDs. Conduct extensive user acceptance testing that demonstrates data and environmental compliance and successful performance of desired functions.

PHASE III DUAL-USE APPLICATIONS: The STID will have a wide appeal within the commercial sector and could be used effectively by a vast portion of military, civilian law enforcement and emergency services, as well as construction firms, the trucking industry, and other industries such as taxi companies. The STID would provide a high-resolution video interface for cellular telephones, other Personal Digital Assistants, as well as military, police, and emergency radios. These displays would permit users to view transmitted maps, location data, pictures, messages, and full motion video. It could also interface with portable CD-ROM or DVD drives to display maps, charts, pictures, full motion video, etc. It could have wide civilian applications.

KEYWORDS: DISPLAY, PORTABLE, WIRELESS, HEAD-MOUNTED, WRIST-MOUNTED, SVGA, VGA, XVGA, VIDEO, STID, PERSONAL DIGITAL ASSISTANT

SOCOM 01-007 TITLE: Tactical Body Worn RF Antenna Vest

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Design and build a rugged tactical body worn radio frequency (RF) receiving antenna to provide threat warning to deployed Special Operation Forces (SOF) missions. The design should use the latest antenna technologies including fractals, patch, composites, conductible cloth, etc., to design a body worn antenna that will receive frequencies from 100MHz to 1GHz (threshold), with the objective of receiving 2MHz to 40GHz. Note, the RF band from 2-40GHz does not have to be continuous coverage, only coverage for bands of known radar emitters.

DESCRIPTION: Today SOF Tactical users normally must stop moving and setup equipment to perform RF detection. This limits their effectiveness to other team members. Our goal in the next generation is to permit on the move hands free RF detection.

We envision the SOF user attaching a receiver and a power source onto his belt or in his backpack, then connecting the receiver via a flexible coaxial cable at a single point on the vest.

The objective will be to design the antenna into common existing SOF tactical web gear or protective vest. The vest can contain a variety of antennas, with the RF combining into a single output that will meet frequency range, VSWR, and directional requirements. Plans should be made for the antenna to pass the RF frequencies to the radio and the radio to pass DC power to the antenna using this single connection. The antennas must take into account multiple possible positions including standing and prone.

We have a requirement for the vest to contain an omni-directional antenna, and an objective that the vest also contain a directional antenna and/or direction finding (DF) antenna.

The omni-directional antenna will have uniform gain (within 3dB) in all directions. It will have a VSWR less than 1.2:1 across the frequency band, with an objective of 1.1:1.

The DF antenna will be composed of at least 8 antennas covering the HF through UHF range, evenly spaced around the soldier. A DF algorithm will be designed to process the signals to determine the location of the signal source. The bidder need not be an expert in DF; SPAWAR Systems Charleston, who is the builder of the receiver that will integrate with the antenna, will assist.

The directional antenna will have at least 6dBi gain forward, and at least 3dBi rejection all other directions. The directional antenna will be placed on the front of the vest (and hence the operator). We envision the directional antenna being composed of multiple antennas, that when combined, covers the required frequency range, and with a ground plane behind the antennas to give directionality.

The vest should contain a small, low power, high dynamic range preamplifier(s) for the LVHF band and above that can be turned on and off, and powered through the RF connection.

Operationally, we envision a tactical user walking along with his team, a receiver on his belt, using the omni-antenna to detect RF energy. When a threat is detected, the SOF user can then change to the DF antenna to locate the direction of the source of the transmission. If the signal is weak, he could then press a button/switch on the vest, and switch to the directional antenna and orient himself to maximize the signal level.

Successful proposals will use novel technology to achieve substantial enhancements to equipment size, weight, performance, reliability, power consumption and/or cost.

PHASE I: Research antenna types that can meet the above objectives and requirements. Develop system design after interaction with SOF tactical users that specifies frequency coverage, antenna types and placement, and DF technology to be used. A decision during Phase 1 will be made on whether to include a directional and/or DF antenna. In addition, research and study the effects (e.g. health) of placing a transmitting antenna in this vest, or using the omni-directional antenna to transmit.

PHASE II: Develop system prototypes (2) and perform antenna gain and VSWR testing. Demonstrate in a realistic tactical environment. Conduct limited testing to prove feasibility over a seven-day mission scenario. Conduct environmental testing to determine feasibility of swimming at a 30-foot depth and subsequent successful operation on the beach and dry land.

PHASE III DUAL-USE TECHNOLOGIES: This system is designed primarily for SOF tactical operations, but will have application with the other military services and law enforcement agencies. Already, Army (Ft. Huachuca) has expressed interest in this SBIR.

KEYWORDS: RF, radio frequency, body worn, antenna, tactical, vest.

SOCOM 01–008 TITLE: NBC Personnel Cooling Suit

TECHNOLOGY AREAS: Chemical/Biological Defense; Human Systems

OBJECTIVE: Design, build and test a lightweight man portable cooling system for use by SOF operators wearing NBC protective clothing. The system shall provide a lightweight self-contained capability to cool the individual operator for a specified duration.

DESCRIPTION: Various new technologies (super cooled liquid air, dry ice, micro cooling, etc.) for personnel cooling have been recently demonstrated. Cooling mechanisms can be passive (evaporative) or active (mechanical). Cooling mediums range from gaseous to liquid cooling mediums. This effort would leverage these existing cooling technologies to develop an innovative cooling system for dismounted personnel applications. The current lack of personnel cooling is the limiting factor for operational endurance when wearing NBC protective garments. Current NBC protective garments subject the users to a significant heat stress burden, limiting their operational effectiveness. In lieu of replacing NBC protective garments, a personnel cooling system will extend the operational effectiveness of the SOF operator. The need for personnel cooling is currently the highest priority for SOF operators in an NBC environment.

PHASE I: Demonstrate an active or passive personnel cooling system concept that provides a minimal cooling capability of 500 watts at a light weight (<15 lb) with a 2 hr duration.

PHASE II: Optimize the Phase I design for operational considerations and demonstrate a personnel cooling system that provides a minimum cooling capability of 500 watts at a lighter weight (<12 lb.) with an improved duration (4 hours +). Additional design considerations include attitude independent operation, shock proof, hardened, air tight, water tight, quick disconnect to suits & supply, check valves at suit penetrators to preclude coolant fluid drainage, and an emergency breakaway disconnect (10 lb.).

PHASE III DUAL USE APPLICATIONS: This system could be used for civilian fire fighting applications and emergency response units upon National Fire Protection Association (NFPA) certification.

SOCOM 01-009 TITLE: Seat/Bolster/Other "New" Approach for Personnel Transport on Special Operations Forces (SOF) Maritime Combatant Craft

TECHNOLOGY AREAS: Ground/Sea Vehicles; Human Systems

TITLE: Shock mitigating, ergonomic seat/bolster for personnel transport on Special Operations Forces (SOF) Maritime Combatant Craft. Priority is to develop an ergonomically correct seat/bolster to provide maximum protection to the human musculoskeletal system of the SOF operator from the injurious and/or debilitating effect(s) caused by chronic exposure to severe and repeated mechanical shock (RMS).

OBJECTIVE: Design and build a seat/bolster which places the SOF operator in the optimum ergonomic position and integrates shock mitigating technology. The seating system must be adjustable to accomadate the 5 to 95 percentile person. The mitigating technology must have an un-damped natural frequency of 1-3 Hz with the inclusion of a damper to provide critical damping. The seat/bolster must fit within current SOF Combatant Craft without effecting craft performance or interfering with the operator's duties.

DESCRIPTION: United States Special Operations Command is responsible for the safe and effective operation of maritime craft used by SOF Forces. In the surface application, these are planing hulls that range from 36 to 82 feet in length. Crew and other embarked SOF Personnel, in typical scenarios, are subjected to mission profiles involving at-sea periods of up to 500 miles and lasting as long as 24 hours. As such, they are subjected to the short term debilitating impact and the long-term injurious prospects associated with prolonged exposure to the effects of RMS.

SOF Combatant Craft are tasked to deliver SOF operators in support of the conduct of their mission. Once the mission is complete, the craft retrieves the operators for return to "base." In the simplest of terms, the combatant craft is a bus for other SOF operators. The physical and mental condition of those SOF operators, when the bus delivers them for mission execution, is of critical importance. This also applies to the supporting crewmen.

SOF Combatant Craft are becoming ever faster. Combined with combatant craft crewmen (NEC 5352) now being able to spend their entire career(s) at the Special Boat Units (SBUs), that has exacerbated significantly a historic medical problem: personnel injury from sustained Combatant Craft OPS. Higher-speed boats have greater accelerations that cause more/severer injuries than slower boats. Personnel can now spend a career with the SBUs; translates over the longer period into enduring more of those higher accelerations.

Craft now have rigid bolster seat arrangements for personnel transport. SBIR purpose is development (and/or identification) of an alternative that is a significant improvement from the current bolster seats' ability to mitigate RMS effects on personnel.

PHASE I: Develop overall system design to include specification of technological approach.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: This system could be used in a broad range of military and civilian applications. Specifically, potential application includes all people going by boat to open water for/over lengthy periods of time. System would mitigate injurious and/or debilitating effect(s) caused by chronic exposure to severe and repeated mechanical shock (RMS).

KEYWORDS: Shock, Mechanical, Hydraulic, Electric,

Office Of The Secretary Of Defense (OSD)
Deputy Director Of Defense Research & Engineering
Deputy Under Secretary Of Defense (Science & Technology)
Small Business Innovation Research (SBIR)

Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) SBIR Program is sponsoring two technology area initiatives this year, Cognitive Readiness Technology and Conditioned Based Maintenance Technology. We are also co-sponsoring two additional technology areas, biomedical technology and information technology for military health systems, with Defense Health Affairs.

All three services are participating in the OSD program this year. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The Army, Navy and Air Force laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) program solicitation.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, DoD Components will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results.

The DoD Program presented in this solicitation strives to encourage technology transfer with a focus on advanced development projects with a high probability of commercialization success, both in the government and private sector. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

The topics are presented in four sections, corresponding to the technology areas cognitive readiness, conditioned-based maintenance, biomedical and information technology for military health systems. The topic descriptions, that follow this program overview section, are listed below.

The Cognitive Readiness Topics are:

- OSD01-CR01 Cognitive Fightability Index for Warrior Systems by the Army Research Laboratory
- OSD01-CR02 Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness by the Army Research Laboratory
- OSD01-CR03 Screening Test for Detection of Major Psychiatric Disorders in Young Adults by the Army Medical Research Acquisition Activity
- OSD01-CR04 3D Components for Virtual Environments By the Army Simulation and Training Command (STRICOM)
- OSD01-CR05 Real Time Collective Performance Feedback For Combat by the Army Research Institute
- OSD01-CR06 Scenario Based Decision Skills Training for Geographically Distributed Teams by Air Force Research Lab Human Effectiveness Directorate, Williams AFB
- OSD01-CR07 Professional Leadership Development Skills Training for the 21st Century by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
- OSD01-CR08 Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
- OSD01-CR09 Cognitive Demands of Warfighter Readiness by Air Force Research Lab Human Effectiveness Directorate, Williams AFB

- OSD01-CR10 Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams by Williams AFB
- OSD01-CR11 Authoring Shell for Case-Based Instruction by the Office of Naval Research
- OSD01-CR12 The Grain Size Of Student Models As A Factor In ICAI Effectiveness by the Office of Naval Research
- OSD01-CR13 Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content by the Naval Air Warfare Center
- OSD01-CR14 Intelligent Assistant for Web-based Training Vignette Design by the Naval Air Warfare Center
- OSD01-CR15 Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills by the Special Operations Command

The Conditioned Based Maintenance Topics are:
- OSD01-CBM01 Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating by Naval Air Systems Command
- OSD01-CBM02 "Smart" Machinery Spaces by Naval Sea Systems Command
- OSD01-CBM03 Fully Automated Bearing Residual Life Prognosis Wireless Sensor by Naval Sea Systems Command
- OSD01-CBM04 Fiber Optic Strain Field Measurement for Aging Aircraft by the Air Force Research Laboratory, WPAFB
- OSD01-CBM05 Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces by the Air Force Research Laboratory, WPAFB
- OSD01-CBM06 In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors by the Air Force Research Laboratory, WPAFB
- OSD01-CBM07 In-line Hydraulic Fluid Contamination Multi-Sensor by the Air Force Research Laboratory, WPAFB
- OSD01-CBM08 Fretting Fatigue Model by the Air Force Research Laboratory, WPAFB
- OSD01-CBM09 Reliability Algorithms for Corrosion Fatigue Assessments by the Air Force Research Laboratory, WPAFB
- OSD01-CBM10 Structural Component Substantiation Methodology by the Army Aviation and Missile Command
- OSD01-CBM11 Power Scavenging in a Cold, Dark Storage Environment by the Army Aviation and Missile Command
- OSD01-CBM12 Battery Optimized for Long Term Storage and Intermittent Use the Army Aviation and Missile Command
- OSD01-CBM13 Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy Related Systems by the Engineering Research and Development Center, Construction Engineering Research Laboratory
- OSD01-CBM14 Smart Coating / Sensor Blankets for Health Monitoring by the Engineering Research and Development Center, Construction Engineering Research Laboratory

The Biomedical Topics are:
- OSD01-DHP01 Development of a Vaccine for the Treatment and/or Prevention of Cancer
- OSD01-DHP02 Development Of A Serum Based Biomarker For The Detection Of Cancer
- OSD01-DHP03 Lightweight Trauma Module
- OSD01-DHP04 Photoactivated Chemical for Tissue Bonding
- OSD01-DHP05 New Biosensors for Real-Time Terrestrial Toxicity Monitoring
- OSD01-DHP06 Rapid Diagnostics for Detection of Respiratory Pathogens
- OSD01-DHP07 Biomarkers of Musculoskeletal Soft-Tissue Injury
- OSD01-DHP08 Production Of Purified Recombinant Proteins For Development Of Vaccines Of Military Importance
- OSD01-DHP09 Reduction of Motion Side Effects and After Effects

The Information Technology for Military Health Systems Topics are:
- OSD01-DHP10 Technology Enhanced Human Interface to the Computerized Patient Record
- OSD01-DHP11 Cognitive Patient-Clinician Encounter Model
- OSD01-DHP12 Health Information Data Mining

SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund these many. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be considered. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully, as well as the Component's specific requirements contained in their respective sections. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

In addition, each of the services and Defense Agencies have developed their own Phase II enhancement policy, which can also be found in there respective sections. The DDR&E topics will follows the Phase II enhancement policy corresponding to the topic author's service. That is, the Army laboratories will follow the Army Phase II enhancement policy, the Navy topics will follow the Navy policy, and the Air Force laboratories topics will follow the Air Force policy. (Refer to their respective sections in this solicitation, or their website for details.)

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract. Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in accordance with the above criteria, and may select these proposals for Phase II award provided:

(1) they meet or exceed seletion criteria (a) and (b) above and

(2) the project has substantially met its Phase I technical goals.

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase II where it is felt that the research and development has commercial potential in the private sector. Proposers who feel that their research and development have the potential to meet private sector market needs, in addition to meeting DoD objectives, are encouraged to obtain non-federal follow-on funding for Phase III to pursue private sector development. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase

II which if met, would justify non-federal funding to pursue further development for commercial purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the point of contact identified in the topic description section. Proposals should be mailed to the address identified for this purpose in the topic description section. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are <u>prohibited</u> for reasons of competitive fairness. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. Each topic has a point of contact to which the proposals shall be mailed. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

DUSD(S&T) Science And Technology Focus Area
Cognitive Readiness

The Deputy Under Secretary of Defense for Science and Technology DUSD(S&T) established a science and technology (S&T) focus area to explore Cognitive Readiness research issue. The Cognitive Readiness focus area provides a cross-component, multidisciplinary S&T framework to focus on the human dimension of joint warfighting capabilities. In addition, Cognitive Readiness serves to highlight a useful criterion for warfighting capability – fully prepared joint-warfighters, fighting and winning in an information rich, distributed firepower battlespace using human-centered hardware and systems.

The Cognitive Readiness focus area is intended to be highly responsive to achieving Joint Vision capabilities. *Joint Vision 2010* identifies readiness, in terms of people, training, leader development, and first-rate equipment, as the foundation for enabling joint operational capabilities. *Joint Vision 2020* reinforces and extends this philosophy by emphasizing and encouraging human innovation as the key force multiplier of the future. Hence, the goal of the Cognitive Readiness focus area is to enable a high degree of Warfighter readiness and mission performance with affordable systems and a smaller force deployed across the globe under diverse conditions. For the full range of weapon systems and Joint Operational Capabilities, Cognitive Readiness technologies are integral to major gains in operability, effectiveness, and affordability.

The optimization and enhancement of human performance is challenged by many different factors, such as general health issues, mental and physical stress, cultural and societal influences, environmental stressors (e.g., heat, cold, altitude, information overload), adequate education and training. Currently, there are two "core" Department of Defense program areas organized to address Cognitive Readiness issues, the Biomedical and Human Systems programs with subcomponents dealing in health, psychology, sociology, personnel and training, and human factors engineering issues.

The Cognitive Readiness topics selected for this solicitation are listed below and are on the following pages:

OSD01-CR01	Cognitive Fightability Index for Warrior Systems by the Army Research Laboratory
OSD01-CR02	Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness by the Army Research Laboratory
OSD01-CR03	Screening Test for Detection of Major Psychiatric Disorders in Young Adults by the Army Medical Research Acquisition Activity
OSD01-CR04	3D Components for Virtual Environments By the Army Simulation and Training Command (STRICOM)
OSD01-CR05	Real Time Collective Performance Feedback For Combat by the Army Research Institute
OSD01-CR06	Scenario Based Decision Skills Training for Geographically Distributed Teams by Air Force Research Lab Human Effectiveness Directorate, Williams AFB
OSD01-CR07	Professional Leadership Development Skills Training for the 21st Century by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
OSD01CR-08	Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics by Air Force Research Lab Human Effectiveness Directorate, Brooks AFB
OSD01-CR09	Cognitive Demands of Warfighter Readiness by Air Force Research Lab Human Effectiveness Directorate, Williams AFB
OSD01-CR10	Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams by Williams AFB
OSD01-CR11	Authoring Shell for Case-Based Instruction by the Office of Naval Research
OSD01-CR12	The Grain Size Of Student Models As A Factor In ICAI Effectiveness by the Office of Naval Research
OSD01-CR13	Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content by the Naval Air Warfare Center
OSD01-CR14	Intelligent Assistant for Web-based Training Vignette Design by the Naval Air Warfare Center
OSD01-CR15	Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills by the Special Operations Command

TOPIC NUMBER: OSD01-CR01 **TITLE: Cognitive Fightability Index for Warrior Systems**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO: U.S. Army Research Laboratory
ATTN: AMSRL-HR-SE (Linda Fatkin)
Building 459
Aberdeen Proving Ground, MD 21005-5425

OBJECTIVE: Develop an index of cognitive fightability through a systematic assessment of fightability attributes of human-centered hardware and systems.

DESCRIPTION: As technologies emerge and are investigated in support of the Joint Vision 2010 and 2020 objectives, developments across a wide range of disciplines tumble over each other in a technological and psychological avalanche. It is necessary to direct these efforts by addressing technological applications from the viewpoint of the soldier, and to assess the practical value added by digital systems to cognitive readiness and force effectiveness.

Cognitive fightability refers to the system's effects on soldiers' capabilities to perform mental functions contributing to optimal performance. Through systematic assessments of cognitive fightability, we can measure the system's enhancement or degradation of human cognitive performance. The Cognitive Fightability Index (CF Index) will be a critical tool when performing trade studies of system components resulting in direct input to system design and manpower requirements.

PHASE I: Identify and evaluate current cognitive taxonomies for their application to fightability classification. Prioritize and define the cognitive fightability attributes or factors in terms of human systems' effects on mental capabilities and task performance. A weighted combination of those factors would yield an overall score or CF Index.

PHASE II: Develop a standardized paradigm for evaluating cognitive fightability and for validating the prototype CF Index. Conduct research studies using the standardized CF paradigm in order to assess system attributes that might constrain or enhance human performance in a variety of contexts. Once validated, the CF Index can be used as a diagnostic tool for evaluating and for predicting human system integration levels within multiple scenarios.

PHASE III COMMERCIALIZATION POTENTIAL: The commercialization potential of this SBIR is extensive. There is a need for a standardized paradigm for evaluating cognitive fightability as a reliable method of quantifying cognitive readiness across a variety of disciplines. Within the private sector, the cognitive readiness index could be applied to the research and development of medical technology, distance learning and leadership techniques, training enhancements, and human systems integration technologies within a variety of other fields.

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KEYWORDS: cognitive fightability, human systems integration, system design decisions, fightability attributes, standardized paradigm, manpower requirements

TOPIC NUMBER: OSD01-CR02 TITLE: Field-Practical Automated Battery for Assessing and Monitoring Cognitive Readiness

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO: U.S. Army Research Laboratory
ATTN: AMSRL-HR-SE (Linda Fatkin)
Building 459
Aberdeen Proving Ground, MD 21005-5425

OBJECTIVE: Develop and validate a field-practical, cognitive readiness assessment battery validated for use within information-rich and high stress environments.

DESCRIPTION: In support of the Joint Warfighting Capability Objective regarding warrior readiness, numerous assessment tools have been developed throughout a wide range of disciplines. These efforts have been relatively isolated, resulting in fragmented methods for evaluating similar concepts. There is a dire need to evaluate the currently disjointed developments of cognitive assessment tools and identify common theoretical and practical frameworks. It is essential that key organizations and commands acknowledge, impart, and bring into play their interdependent capabilities for cognitive assessment. A gold standard for cognitive assessment batteries has been the Unified Tri-Services Cognitive Performance Assessment Battery. It is essential to build on those synergistic efforts established in the late 80's and incorporate recently developed assessment tools, such as noninvasive physiological measures, into current applications.

PHASE I: Develop a field-practical, automated tool capable of assessing cognitive readiness and stress resiliency within a variety of military scenarios. Cognitive readiness is defined as an enhanced state of mental acuity necessary for the warfighter to accomplish the mission while maintaining situational awareness of the operational environment. The "operational environment" typically includes varying intensities and durations of stressors. Consequently, in addition to measuring cognitive readiness, the assessment battery should include a standardized, yet noninvasive, physiological stress measure as an integral component of an overall stress metric. Efforts in Phase I must be coordinated with key cognitive researchers within the DoD, including the USAMRMC (WRAIR), the AFRL, the ONR, and other subject matter experts.

PHASE II: Develop a standardized paradigm to evaluate the multidimensional automated assessment tool within digitized scenarios and in urban environments as well. Conduct collaborative research investigations (a compendium of military agencies, academia, and industry) to validate the cognitive readiness battery and to mobilize mutually supporting efforts across various disciplines. This phase should culminate in the demonstration of the prototype battery.

PHASE III COMMERCIALIZATION POTENTIAL: The commercialization potential of this SBIR is extensive. There has been a significant need for a comprehensive, automated cognitive readiness battery within the private sector, particularly in areas such as private and public education (from pre-K through the college years), medicine, distance learning and leadership, training performance, adaptation to extreme environments, social cognition, human systems integration, and health, morale and welfare. As the automated battery is demonstrated and marketed in these areas, the potential for application to an extended range of other applications is phenomenal.

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KEYWORDS: cognitive readiness, cognitive assessment tools, automated battery, field-practical tool, collaborative research

TOPIC NUMBER: OSD01-CR03 **TITLE: Screening Test for Detection of Major Psychiatric Disorders in Young Adults**

DOD TECHNICAL AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop a rapid, inexpensive method to screen military recruits for major psychiatric disorders or other behavioral factors that strongly predict occupational dysfunction in the military. Results should be standardized and interpretable by physicians without specialty training in psychiatry. The screening test should be reliable, and valid without significant health risk to persons tested. The goals are to identify individuals who may have psychiatric disorders which should be addressed prior to entry on active duty, as well as the early detection of conditions that could be addressed with appropriate intervention, thereby reducing attrition among those on active duty.

DESCRIPTION: Psychiatric disorders are common in young adults aged 17 to 25 which is the age-range of most of those applying for military service. Currently, there is no reliable screening tool used to identify those individuals at risk of having a mental health problem prior to accessing into the Army. Various screening programs that have been tried in the military have given inconsistent results. Psychiatric disorders are the number one cause of existed prior to service (EPTS) medical discharges from the military. In 1998, approximately 30% of all EPTS discharges were due to psychiatric conditions. The majority of these conditions were concealed at the time of accession to the military. These losses cost the military more than an estimated $27.3 million in 1998 in recruiting and accession costs alone (figure excludes costs of medical care, subsequent disability discharges, and associated attrition).

A simple screening tool during the application process might help identify those who should not enter active duty, as well as identify those who would benefit from appropriate interventions (e.g. mental health counseling, life skills training, etc.) while on active duty. For example, one study has shown that those identified to be at higher risk of developing depression during basic training have been helped by cognitive group therapy to gain the necessary coping skills to complete basic training process (personal communication, Dr. Reg Williams 8/00). Psychiatric disorders in young adults compromises the DOD's ability to recruit, access, train, and retain the manpower force needed to fulfill its global missions. A simple inexpensive screening test to use on a large number of individuals to detect common psychiatric disorders in young adults is needed to prevent the significant monetary and manpower losses to the military from premature attrition

PHASE I: Develop the feasibility concept design for new screening methodology to identify individuals at risk for the most common psychiatric disorders. Possibilities include, but are not limited to screening questionnaires or psychoactive pharmaceutical detection (to identify those who recently discontinued psychiatric medications). The screening methodology should be inexpensive and simple to use, and suitable for administration to large groups of individuals.

PHASE II: Demonstration of a prototype screen with measures of sensitivity, specificity, positive predictive value, and ease of correct performance of the test. The goal would be to reduce psychiatric related attrition from initial entry training by 10% or greater.

PHASE III DUAL USE APPLICATIONS: Psychiatric disorders is a major cause of expenditure of resources in the health care industry for civilian populations as well as the military. A psychiatric disorder screening methodology that could be used in a primary care setting offers the potential to correctly diagnose these common conditions in a timely and cost efficient manner, and ensure these individuals are medically managed appropriately. This methodology offers the potential of assessing the severity of the disorder and monitoring the response to therapy.

KEY WORDS: Mental disorders, screening, academic skill defects.

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TOPIC NUMBER: OSD01-CR04 **TITLE: 3D Components for Virtual Environments**

DoD Critical Technology: Human Systems, Personnel Performance and Training

MAIL ALL PROPOSALS TO: Rodney Long
STRICOM – AMSTI-ES
12350 Research Parkway
Orlando, FL 32826

OBJECTIVE: Develop a framework and supporting authoring tools for the structured design of 3D content based on reusable components. The tools will support the development of Advanced Distributed Learning (ADL) environments and shall be conformant with the Sharable Content Object Reference Model (SCORM).

DESCRIPTION: In November 1997, the Advanced Distributed Learning (ADL) initiative was launched to ensure access to high-quality education and training materials that can be tailored to individual learner needs and made available whenever and wherever they are required. This initiative is designed to accelerate large-scale development of dynamic and cost-effective learning software and to stimulate a vigorous market for these products in order to meet the education and training needs of the military and the nation's workforce in the 21st century. Through the SCORM, the ADL initiative is developing a common technical framework for computer and Web-based learning that will foster the creation of reusable learning content as "instructional objects."

With technical advances in personal computers such as advanced graphics cards, faster processors, increased memory, and high speed modems, the use of 3D graphics over the World Wide Web has become widespread. While gaining popularity in the entertainment and e-commerce areas, the use of 3D content can also be very effective in educational environments, providing information visualization and interactive training simulations. However, there is still a lack of design experience and dedicated tools that allow the seamless integration of interactive 3D components in today's multimedia applications. 3D applications are usually developed from scratch, using tools that are very complex and require computer programming skills and expert knowledge of computer graphics, resulting in unacceptable development costs. In addition, the graphics developer is not the subject matter expert for the application content. What is needed is a development environment with a level of abstraction that hides the complexities of computer graphics and programming languages.

Current research has applied the concept of reusable components and frameworks to 3D computer graphics to provide this abstraction. 3D components are visual objects that have geometry and behavior. The geometry defines the shape of the object, size, color, etc. In addition, the 3D component may also have an associated behavior that causes it to change state, produce animations, and react to user input. The behavior can also cause changes in the component's geometry. A component's geometry and behavior must be encapsulated. In other words, the component is treated as a black box that is only accessible through a well-defined interface. Using the component interface mechanisms, 3D components can be integrated together to form new and more complex visual objects in a virtual environment.

Once the component interface mechanisms and framework have been defined, supporting authoring tools are required. These tools provide a level of abstraction that allows a content expert to assemble the components into a dynamic virtual environment to support ADL. The tools must provide a repository of reusable components with a taxonomy that is intuitive in assembling the components. Providing a framework and supporting authoring tools for 3D components will reduce development costs by managing the complexity of 3D development, encouraging reuse, and allowing the content expert to participate in the development process.

PHASE I: Develop a framework for the structured design of reusable, 3D components. Define component interfaces and how the geometry and behavior of dynamic 3D components will be encapsulated to promote reuse. Describe the development/authoring tools that will allow the reusable components to be combined to create a virtual environment. Using the SCORM, define the concept of a reusable learning object for this environment and how the SCORM's Application Program Interface (API) and metadata tags would be implemented.

PHASE II: Develop a prototype of the authoring tool, implementing the framework. Using the authoring tool, develop a small training application demonstrating reuse and reduced development costs and the ability to import and export content objects using the SCORM.

PHASE III DUAL-USE COMMERCIALIZATION: Provide a commercialized toolset that supports development of 3D virtual environments for ADL. The toolset could also have a wide range of applications including entertainment and information visualization.

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KEYWORDS: Virtual Environments, 3D Graphics, Components, Sharable Content Object Reference Model, Advanced Distributed Learning, Reuse

TOPIC NUMBER: OSD01-CR05 **TITLE: Real Time Collective Performance Feedback For Combat**

DOD Critical Technology: Cognitive Readiness

OBJECTIVE: Demonstrate value of providing realtime collective performance feedback supporting combat mission execution.

MAIL PROPOSALS TO: U.S. Army Research Institute
Simulator Systems Research Unit
ATTN: Dr. Goldberg
12350 Research Parkway
Orlando, FL 32826

DESCRIPTION: After action review (AAR) aids illustrate key aspects of collective performance and provide military organizations with an improved perspective regarding exercise events. The need for timely feedback after collective training exercises has resulted in the development of automated AAR systems capable of creating AAR aids during exercises, with minimal operator interaction, for immediate use when the exercise ends. The state of the art of automated AAR systems allows non-programmers to change the rule sets guiding automated AAR aid production to fit specific exercises as illustrated by the Automated Training Analysis and Feedback System project and the ongoing upgrade of the Close Combat Tactical Trainer AAR system. The state of the art is also moving towards feedback systems that are embedded in operational systems, as illustrated by the Navy's Advanced Embedded Training Advanced Technology Demonstration (AET-ATD). The state of the art in feedback systems is also moving towards automated support of process-oriented measures of team performance as illustrated by the Shipmate project. This research is the logical follow-on to the Navy's AET-ATD. It expands the AET concept from individuals and small teams to larger, combined arms units. It also investigates the efficacy of online feedback beyond training applications to operational combat missions. Digitization of the battlespace has created a situation where much of the data used to create AAR aids in the constructive, virtual or live instrumented range environment can now be made available in the actual combat environment. We have the potential to provide organizations with feedback in time to take corrective actions by employing AAR systems as operational tools. The transition of AAR systems to an operational tool also provides a means of helping units address the explosive growth of data within the digitized battlespace.

PHASE ONE: This phase will produce a feasibility concept design for an operational realtime collective performance feedback system that exploits the availability of digital data. The first objective of this phase is to identify unit performance measurement targets of opportunity for demonstrating the value of an operational collective performance feedback tool for digitized units. The concept for the demonstration must employ only those sources of data that would be available to a unit in a combat environment.

The concept must also avoid data collection and analysis activities that require additional staffing. That is, it should be possible to implement the concept using personnel that would normally be available in a mission situation. The second objective is to propose a low cost hardware and software approach to demonstrating the value of the concept in an Army exercise environment.

PHASE TWO: This phase will culminate in the demonstration of a prototype. Prototype software and procedures should be developed and applied to demonstrate the value of using an AAR system to provide digitized units with realtime feedback

PHASE III DUAL-USE COMMERCIALIZATION: The capability for providing collective performance feedback during task execution is particularly well suited to cases where the task is performed over a relatively short period of time, outcomes are highly critical, a mix of organizations must work together in performing the task, and one or more electronic data streams can be applied. The cooperative actions of federal emergency management administration, law enforcement, medical, fire, and location officials in responding to a natural or manmade disaster is an example of such a task. It is also a target application area where AAR aids have been employed to support post training exercise feedback sessions.

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2) Digital Systems: OC Smart Books providing brief descriptions of individual digital systems are available at www.atsc.army.mil/ warmod/Warrior-T/products.html
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4) Navy Embedded Training and Team Training Measurement Techniques: A list of publications in this area can be found at http: www.ntsc.navy.mil/Org/CODE4/496/Bibliography/NewTT_Bib_2_TeamTr.htm. Publications likely to be available to a wide audience include: (a) Zachary, Bilazarian, Burns, and Cannon-Bowers (1997). Advanced embedded training concepts for shipboard systems in the Proceedings of the 19th Annual Interservice/ Industry Training System and Education Conference, Orlando, FL (CD-ROM) (b)Smith-Jentsch, Johnston, Cannon-Bowers, and Salas (1997). Team dimensional training: A Methodology for enhanced shipboard training in the Proceedings of the 19th Annual Interservice/ Industry Training System and Education Conference, Orlando, FL (CD-ROM).
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TOPIC NUMBER: OSD01-CR06 **TITLE: Scenario Based Decision Skills Training for Geographically Distributed Teams**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO: Ms. Sabrina Davis
Human Effectiveness Directorate AFRL/HEOP
2610 Seventh Street, Bldg. 441, Rm. 216
Wright-Patterson AFB OH 45433-7901
Phone: (937) 255-2423 ext 226

OBJECTIVE: To develop, implement, and evaluate a scenario-based, distributed training system to enhance team, decision-making skills.

DESCRIPTION: Recent research across the services has demonstrated that team participation in scenario-based training exercises greatly enhances problem solving and decision making skills. Work conducted by the Army Research Institute emphasizes a structured approach to scenario-based training (Campbell, Quinkert, and Burnside, 2000). Researchers from the Naval Air Warfare Center's Training Systems Division have developed the Team Dimensional Training approach to enhancing performance of shipboard teams by focusing on the processes a crew employs to accomplish its objectives (Smith-Jentsch et al, 1998). Distributed Mission Training research conducted by the Air Force Research Laboratory emphasizes skill enhancements resulting not only from mission practice but also from inter-team interaction before the mission: planning and briefing, and after the mission: review and after-action analyses, (Crane, Robbins, and Bennett, 2000). Marine Corps squad leaders are using table-top tactical scenarios to improve their decision-making skills before engaging in field exercises (Pliske, McCloskey, and Klein, 1998). Further, this research is demonstrating that the most notable improvements in performance are for cognitive skills such as

maintaining situation awareness and for skills requiring interactions among teams of warfighters who are normally geographically distant from each other such as fighter pilots and air weapons controllers. In future deployments, combat and combat-support teams from different units will be tasked to arrive in theater and quickly begin composite force operations. Research is required to design and develop scenario-based, home station training systems for these warfighters with the goal of enhancing team and inter-team skills and reducing spin-up time in theater.

PHASE I: Prior to Phase 1, resources for training geographically dispersed groups of combat-support personnel such as medical services or environmental health will be researched by the government and references including websites containing this information will be provided to contractor. During Phase 1, an initial cognitive task analysis will be conducted to identify the knowledge, skills and experiences required for competent mission performance. Phase 1 will conclude with a feasibility design of a distance, decision training system.

PHASE II: The goal of Phase 2 will be to fully develop and demonstrate the distance, decision skills training system. The products of Phase 2 will include the prototype system, sample training scenarios, and an architecture for developing similar systems for other specialties.

PHASE III: Distance decision skills training systems will have applications for any endeavor that requires rapid setup and coordination of multiple teams performing a common mission. Examples include emergency response teams (fire, police, hazardous materials, medical) and reactions to natural disasters (medical, civil preparedness, government). Phase 3 will incorporate laboratory and field trials of a productized system for the selected application.

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KEYWORDS: Cognitive task analysis; decision making; problem solving; deployment

TOPIC NUMBER: OSD01-CR07 **TITLE: Professional Leadership Development Skills Training for the 21st Century**

DoD CRITICAL TECHNOLOGY: Human Systems; Information Technology

MAIL ALL PROPOSALS TO: Ms. Sabrina Davis
Human Effectiveness Directorate AFRL/HEOP
2610 Seventh Street, Bldg. 441, Rm. 216
Wright-Patterson AFB OH 45433-7901
Phone: (937) 255-2423 x 226

OBJECTIVE: Design and development of a computer-based simulation training system prototype for professional military leadership skills development.

DESCRIPTION: Critical to the development of current and future military leaders, is the ability to provide more effective skills training which takes into account dynamic, uncertain environments endemic to the 21st century. Changing mission requirements, and the implosion of the information age are placing our current and emerging military leaders into positions for which they can be ill equipped. This is due to lack of experience, training, or guidance, and compounded by a need to consider a myriad of legal, moral, and ethical processes and procedures that has and will become inherent in 21st century. The need therefore exists to improve current leadership development skills training to enable our leaders to face the myriad of challenges necessary to move their 'forces' toward warfighter readiness and mission performance effectiveness. It is envisioned that leadership development may be optimized and enhanced by providing education and training in both cognitive and non-cognitive skills development. The proposed research is therefore directed toward exploring the feasibility of designing and developing a computer-based training system prototype consisting of cognitive (e.g., critical thinking, problem solving, etc) and non-cognitive (e.g.,

motivation, emotional control, etc.) modules designed to teach such skills identified as required, or deemed essential for effective leadership development. The training system as well as the modules must demonstrate sound theoretical constructs, instructional strategies and modeling approaches, integrate a simulated practice environment and provide feedback. Additional characteristics of the training system will include: (a) a computer-managed instruction (CMI) tool to track and document student progress; (b) plug and play capability; and (c) conform to DIICOE standards and guidelines for utilizing commercially available off-the-shelf software/hardware ensuring compatibility across platforms, domains, etc. The training system will be developed for implementation via an internet/intranet environment and/or packaged as a stand-alone system.

PHASE I: This phase will consist of an identification of what types of cognitive and non-cognitive skills should be taught within the training system as well as justification for why these skills should be included. A further product of Phase I will be a comparison and contrast of various methods for teaching the types of leadership skills of interest as well as the feasibility of these methods within a computer-based environment. Results will be documented in a technical report at the end of Phase I, to include a plan for Phase II work to include how the proposer would develop and implement a training module to teach at least one cognitive and one non-cognitive skill for leadership development.

PHASE II: Design, development, and demonstration of prototype, to include cognitive and non-cognitive skills modules, scenarios; design, develop, and execute a test and evaluation of the prototype, with objective to produce fully functional product to commercialize in Phase III.

PHASE III: Tri-service, industry, and other commercial application.

REFERENCES:

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KEYWORDS: Decision-making, emotional intelligence, cognitive skills, instructional strategies

TOPIC NUMBER: OSD01-CR08 **TITLE: Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO: Ms. Sabrina Davis
Human Effectiveness Directorate AFRL/HEOP
2610 Seventh Street, Bldg. 441, Rm. 216
Wright-Patterson AFB OH 45433-7901
Phone: 937-255-2423 ext 226

OBJECTIVE: Conduct research to develop tactics, training, and procedures for users of lethal and Non Lethal Weapons (NLWs) that would enhance their ability to rapidly assess the situation and determine the optimal course of action. Rapid and accurate assessment of potential agitation indicators in a crowd allows for better real time decisions and optimizing the applied force required to meet mission objectives while minimizing the level of conflict escalation.

DESCRIPTION: Cognitive readiness is critical to ensuring that today's and tomorrow's warfighters have superior and supportable technology to support their mission and to give them revolutionary war-winning capabilities. Emerging war-fighting concepts, for example, have multi-disciplinary teams deployed in support of the joint/combined air operations center and in response to acts of terrorism. Operations, across the spectrum of missions, must support surge/sustained taskings, resolve situational ambiguities, and mitigate data overload in order to produce decision-quality information for the commander. Innovative training and procedures are required to conduct rapid assessment of the crowd and determine the use of lethal and NLWs. Training for the use of conventional weapons has focused on pre-conflict planning to recognize crowd behavior and to identify motivational factors and cultural issues. Training that aids the warfighter in making rapid and accurate reactive decisions based on feedback from the crowd's behavior has not been adequately addressed. Developing and enhancing these reactive decision-making processes in those making lethal and NLW employment decisions would lower the probability of conflict escalation.

PHASE I: Emphasis will be on the role of the warfighter in the global theater. The impact of the threat will be analyzed with respect to the decision-making process. Conduct research to identify factors that could influence crowd behavior or mood (e.g., size, motivation, age range, cultural diversity). Identify existing training courses that use these factors to assess possible military action. Identify data regarding historical crowd behaviors (Chicago, 1968, Seattle, 1999) and consequences of the applied security responses. Develop an understanding of how actions by military or police forces modify crowd behavior based on the identified crowd behavior indicators. Define which courses of action were most beneficial in reducing crowd escalation. The methodology and findings will be documented in a technical report.

PHASE II: Conduct research required to develop tactics, training, and procedures that include Prepared Responses (e.g., crowd size, motivation, age range cultural diversity), but focuses on Reactive Responses (i.e., using feedback from the crowd to determine the decisions leading to the lowest level of escalation). Attention must be given to the manner in which the information is conveyed to the commander in order to produce decision-quality information without data overload. Computers and other information tools that are used to assess the situation and convey the information must be, from the crew-system interface perspective at least, compatible with both the operational tasks to be performed and the physical environment in which they are being conducted. Addressing these topics would aid the warfighter in determining the relevance, pertinence, and applicability of lethal and NLWs. Training effectiveness assessments would be conducted.

PHASE III DUAL-USE COMMERCIALIZATION: The developed tactics, procedures, and training course might be taught on a contract basis to military, government, and commercial customers. As an example, the developed course might be incorporated into broader courses, such as the Interservice NLWs Instructor Course (INLWIC) in Fort Leonard Wood, Missouri. In addition, the developed course would be applicable to numerous security forces, especially those using both lethal and NLWs (e.g., SWAT). In addition, the tactics, training, and procedures developed for assessing crowd dynamics would be applicable to humanitarian and crisis response teams situated in potentially hostile environments.

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5) Air Force Doctrine Document 2-5, "Information Operations," 5 August 1998 http://www.dtic.mil/doctrine/jel/usaf.htm
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KEYWORDS: Chaos Theory, Cognitive Engineering, Human Factors, Information Warfare, Non Lethal Weapons, Psychology

TOPIC NUMBER: OSD01-CR09 **TITLE: Cognitive Demands of Warfighter Readiness**

DoD CRITICAL TECHNOLOGY: Human Systems

MAIL ALL PROPOSALS TO:

Ms. Sabrina Davis
Human Effectiveness Directorate AFRL/HEOP
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OBJECTIVE: Identify the cognitive skills that contribute most heavily to effective combat mission planning for aviators, develop training interventions designed to develop these cognitive skills, and evaluate the impacts on subsequent mission planning performance.

DESCRIPTION: Researchers across the services are documenting an opportunity to enhance mission performance by improving mission planning and briefing (Nullmeyer, R.T., Crane, P., Cicero, G., & Spiker, V.A., 2000; Stout, R.J., Cannon-Bowers, J.A., Salas, E., & Milanovich, D.M., 1999). The Department of Defense is investing considerable resources to develop and field computer-based mission planning tools to support pre-mission activities. Other efforts are providing enhanced systems in the cockpit to provide near real time tactical information for aviators. In both cases, training for operators focuses mostly on

equipment operation with little attention being paid to identifying and developing underlying cognitive skills. The generally low experience levels in today's crew force allow less time for "on the job" training, further increasing the need for active instructional interventions to develop such skills. Distributed Mission Training (DMT) has the potential to support such interventions (Nullmeyer, et.al, 2000). Research is needed to identify the skills required in both mission preparation and replanning during mission execution for effective performance, develop training interventions to develop these skills, and assess the impacts of the resulting training treatments.

PHASE I: The research team will develop a set of targeted planning skills through a review of existing DMT and mission planning and replanning reports, interviews of DMT participants to identify mission areas that are particularly sensitive to mission planning and replanning skills, and conduct of cognitive task analyses. Phase I will conclude with development of a feasibility concept design for training interventions that are designed to take advantage of DMT capabilities to develop critical mission preparation and replanning skills.

PHASE II: The outcome of this phase is a prototype demonstration of training interventions used in conjunction with DMT to improve the planning and replanning skills of aviators. The Phase I feasibility design concept will serve as the foundation for developing training interventions that are designed to enhance mission preparation and replanning skills. The impacts of this training on the performance of warfighters will be evaluated, and results will be used to fine-tune the training treatments. The domain selected for assessing the effectiveness of these interventions will include scenarios that were not used as primary Phase I data sources.

PHASE III: A validated training package with demonstrated ability to enhance mission planning and replanning skills has applicability across the services. In addition to aviation, the importance of these skills is recognized in a wide variety of dynamic task settings such as medicine and nuclear power plant operations.

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KEYWORDS: Cognitive task analysis, mission planning, decision making, problem solving

TOPIC NUMBER: OSD01-CR10 **TITLE: Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams**

DoD CRITICAL TECHNOLOGY: Information Systems Technology, Human Systems

MAIL ALL PROPOSALS TO: Ms. Sabrina Davis
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OBJECTIVE: Develop automated methods to assess Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation and Dissemination (TPED) Teams.

DESCRIPTION: This effort will conduct research to develop distributed, collaborative methods and criteria to systematically assess the knowledge acquisition and cognitive performance and readiness of warfighting teams. Of primary focus will be teams associated with the intelligence tasking, processing, exploitation and dissemination (TPED) process needed to support the Combined Air Operations Center (CAOC) and the AF Distributed Common Ground Station (DCGS). The DCGS is the primary integration cell for ISR in the Air Force. Of primary focus will be the generation of scenario-based knowledge assessment items and criteria related to the cognitive components of mission essential competencies which are required by operators and commanders in the CAOC/DCGS site. It will further provide a means of identifying instructionally valid strategies for remediating and refreshing specific and shared knowledge and skills which could be used to inform the design of simulation-based training and rehearsal events. A capability to automatically conduct knowledge assessments to evaluate the impact of simulation-based training and rehearsal technologies and to design instructional content (e.g., missions and scenarios) to foster knowledge acquisition and retention at team levels of analysis does not exist today. Ultimately, a distributed, collaborative

approach to assessing the acquisition of complex knowledge provides critical information about how the team develops knowledge about, and improve their cognitive readiness regarding, critical tasks. These assessments are foundational in terms of specifying the content and structure of initial training, refresher training content and intervals, and just-in-time interventions that promote enhanced cognitive readiness. Moreover, a technology such as this could be used to assess the relative contribution of team member's knowledge to performance in a given intelligence synthesis and dissemination situation and data on their actions and responses. The data can be used to identify innovative solutions, misconceptions about the appropriate solution, and incorrect information that could be addressed in follow-on training and rehearsal activities. Similarly, teams with specific knowledge related to a given mission can be identified, assembled, and assessed more readily if relevant, objective knowledge acquisition measures are developed and used.

PHASE I: Phase I activities will result in proof-of-concept software methods defining critical CAOC/DCGS knowledge requirements and mission essential competencies for aerospace superiority missions. Phase I will also demonstrate the feasibility of developing an automated knowledge acquisition and assessment system for teams within the DCGS. As a precursor to Phase II activities knowledge assessment outcomes will be matched to training strategies for training and remediation. Phase I will also provide specifications for an integrated knowledge assessment and acquisition system specifically focused on teams.

PHASE II: Phase II will develop and demonstrate a suite of tools, techniques, methods and a common architecture for assessing the knowledge acquisition of warfighting teams in aerospace combat environments such as those supported by the CAOC/DCGS. As an additional activity in Phase II, an elaborated knowledge decomposition and analysis capability will be developed and delivered.

PHASE III DUAL USE COMMERCILIZATION: This effort will provide an integrated suite of tools, technologies and a general architecture for assessing knowledge acquisition for training and rehearsal. The benefits from such a capability to government and private sector agencies include targeting training and rehearsal activities and content to remediate specific knowledge shortfalls and reducing operator time-to-proficiency and error-rates.

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KEYWORDS: Affordability, Criterion development, Knowledge acquisition, Knowledge assessment, Performance measurement, Readiness evaluation, Team effectiveness, Workgroup effectiveness

TOPIC NUMBER: OSD01-CR11 **TITLE: Authoring Shell for Case-Based Instruction**

DoD Critical Technology: Advanced Distributed Learning

MAIL ALL PROPOSALS TO: Dr. Susan Chipman
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800 N. Quincy Street
Arlington, VA 22217-5660

OBJECTIVE: Develop an authoring shell that supports the effective use of case-based instruction in a wide range of applications to the development of complex skills.

DESCRIPTION: Case-based instruction is a major alternative instructional approach widely used in management training and certainly applicable as well to high level military training dealing with tactical and strategic decision making. Yet, there is little research on the process of case-based instruction and the design features that will maximize its effectiveness. A distinct instructional technology for case-based instruction has yet to emerge. Recent research by Gentner and Forbus of Northwestern University provides basic research foundations for what could become a new form of instructional technology for case-based

instruction, especially for just-in-time training for major military decisions. Gentner and Forbus have studied how people retrieve potential analogous cases from their memories and how they make analogies and judge the quality of those analogies. They have done computational modeling of these mental processes as well. These computational models could form the basis of a system that could, for example, draw upon a large database of case examples to find those that would be considered good analogous cases to work with in preparing to address a new military decision making problem. Unfortunately, unaided human memory tends to retrieve cases with superficial resemblances to the present problem, whereas what humans judge to be good analogies depends upon deeper structural similarities. One reason for the instructional use of case examples is the belief that their rich contextual information will assist students in recognizing situations in which problem solving techniques they are learning can be applied. Some additional recent research by Gentner and collaborators in the school of business has shown that small differences in the way such cases are used instructional can make a big difference in the success of such knowledge transfer. An authoring shell for case-based instruction would help ensure that such more effective instructional methods are implemented.

PHASE I: In Phase I, the proposed authoring shell should be designed in detail, including the conceptual design for applications that would be produced with this authoring shell. A military-relevant application for which a body of case materials exists should be identified, perhaps in collaboration with an institution such as the National War College. Thought should be given to ways of incorporating systematic instructional objectives into the system, along with an individually adaptive intelligent tutoring approach to ensuring attainment of those objectives. The design should provide for web-based instructional delivery.

PHASE II: The authoring tool and demonstration application should be developed and demonstrated. The demonstration application should receive a practical evaluation with members of the target population of students.

PHASE III DUAL-USE COMMERCIALIZATION: Given the extensive use of case-based instruction in management training, this system should have high commercial potential both as a product in its own right and as the foundation for one or more business operations specializing in the development of case-based instructional products.

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KEYWORDS: Training technology, case-based instruction, military decision making.

TOPIC NUMBER: OSD01-CR12 **TITLE: The Grain Size Of Student Models As A Factor In ICAI Effectiveness**

DoD Critical Technology: Advanced Distributed Learning

MAIL ALL PROPOSALS TO: Dr. Susan Chipman
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OBJECTIVE: Determine how the grain size of student models impacts the effectiveness of artificially intelligent tutoring systems and build a generic tutoring engine appropriate for the grain-size determined to be most cost-effective.

DESCRIPTION: Over the last decade much research has been conducted to demonstrate the effectiveness of artificially intelligent tutoring technology. Overall, this research has found significantly improved student performance with the use of intelligent tutors, typically about one standard deviation improvement in achievement. Although, we know that these tutors are effective, they are very complex systems incorporating many instructional features. We do not know which of the components within the tutors account for most of the student learning. Many of the instructional features of the most successful tutors have very significant costs associated with them, so that decision makers in DoD training have a need to know what the value of these features is in order to maximize the cost-effectiveness of training as artificially intelligent tutoring moves toward practical implementation. For example, we do not know how fine-grained the student model needs to be. . The most successful family of intelligent tutors is based on a very fine-grained model of expertise, and this research group is now moving towards even more fine-grained models. Other intelligent tutors have used a much coarser level of description in their student models. We need to know how much added value there is from the more costly fine-grained model. In order to make this effort feasible within the financial constraints of the SBIR program, bidders should own or obtain the rights to work with a tutor or cognitive model at the fine production system level of description. Tutors can then be developed that adapt instruction to one or more coarser grained student models, such as models defined at the level of instructional objectives. A comparative instructional evaluation should then be conducted to determine how much the effectiveness of the tutor is affected by the grain size of the student model.

PHASE I: The proposal for Phase I should identify the fine-grained cognitive model or cognitive model and existing tutor to be used in the research effort. In Phase I, the study design should be developed in detail, including development of the more coarse grained models of the skills to be taught. Information about the costs of cognitive task analysis and cognitive model development should be recovered and analyzed and costs of development of the less fine-grained models alone estimated, in order to provide the cost element of a cost-effectiveness estimate.

PHASE II: In Phase II, development of the competing tutors must be completed and a comparative learning experiment conducted. In addition, the generic tutoring engine should be developed, work that should be integrated with the development of the tutors themselves.

PHASE III DUAL-USE COMMERCIALIZATION: .Ownership of a tutoring engine which this research has shown to be at a cost-effective grain size should position the company well for further business developing intelligent tutoring systems for both DoD and commercial industrial customers.

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KEYWORDS: Training technology, artificially intelligent tutoring, cost-effectiveness of training

TOPIC NUMBER: OSD01-CR13 **TITLE: Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting and Motivating Instructional Content**

MAIL ALL PROPOSALS TO:

Naval Air Warfare Center Training Systems Division
Attention: Bob Seltzer, Code 4.9.T
12350 Research Parkway
Orlando, FL 32826-3275
phone:(407)380-4115

OBJECTIVE: The purpose of this SBIR is to explore concepts leading to the development of a tool for designing or reworking web-based training content so that is inherently interesting, engaging, and motivating. Desired capabilities include the compatibility with Department of Defense (DOD) distributed learning networks, compatible with elements of the Shareable Content Object Reference Model (SCORM) and related standards, design of learning objects based upon reasonable instructional models, user selectable options, open modular architecture, and a web-based interface.

DESCRIPTION: Distance learning (DL) has been identified as an instructional tool that can significantly contribute to the development of high levels of skills and knowledge necessary to deal with increasingly complex weapon systems and wider ranges of missions. Content elements need to be sufficiently small so that they can stored in content repositories for re-purposing and reuse. But, less attention had been directed to the quality of the instructional content. There are tens of thousands of existing content products that could be converted to the SCORM model and related standards, and well as many new courses to be developed in a web-based format. It is well known that web-based instruction may not be as interesting and motivating as other methods of instruction. Web-based instruction may be boring and lack-luster. The drop-out rate in web-based training is higher than in the traditional classroom. In part, this may be due to lack of social interaction in the web-based training environment. There are many useful tools that can be used to create pedagogically correct instructional content, but practical guidelines and tools are needed to help instructional designers to produce content that is also interesting, engaging and motivating. Ultimately, the product should be composed of a toolbox of strategies and an intelligent advisor to help the developer match strategies to the particular material. The toolbox should include several major categories of motivational tools: (1) social interaction (e.g., incorporating on-line collaboration with other students);
(2) dynamic graphics and sound effects; and (3) gaming strategies (e.g. incorporating imaginary situations, competition, challenge, simulated danger, high response rates). The intelligent advisor should include an interface that would query the developer regarding characteristics and uses of the training content. Together, the intelligent advisor and the toolbox will make suggestions and provide guidance for possible ways to enhance existing content (ultimately the training developer may choose which tools to use), guide the developer through the steps necessary to implement the strategies, and evaluate the training effectiveness of the implementation.

PHASE I: Explore alternative approaches and the feasibility of an on-line tool for the development of pedagogically correct yet interesting and motivating courseware. The contractor shall formulate detailed plans for 1) building a prototype assistant and 2) testing its usefulness and effectiveness. The plans for the prototype shall provide justification for the chosen content based upon an in-depth understanding of Navy, Marine Corps, Air Force, Army, or DoD DL requirements. It shall be capable of installation on an existing Department of Defense DL network (e.g., Navy ADL, Marine Net, Total Army Distance Learning Program, or the DoD ADL Co-Laboratory). The plans for prototype development shall also include methods to ensure compliance with DoD SCORM for the resulting content.

PHASE II: Following the plans formulated during Phase I, the contractor shall provide a more detailed analysis of the specific context for development and implementation. The contractor shall then develop, test, and demonstrate the prototype motivational tool.

PHASE III: The contractor shall produce a technology demonstration based on the prototype system developed under Phase II. This technology demonstration will consist of reworking an existing web-based training course using the motivational tool, and the content will be evaluated at a DoD training facility.

COMMERCIAL POTENTIAL: There are many potential applications for a tool to improve the quality of content within and outside the military. Many commercial organizations are using DL to train their personnel in a wide variety of tasks. Once the tool has been shown to improve interest and motivation in military distance learning, we expect that commercial developers will be eager to use it as well.

KEY WORDS: distance learning; SCORM; motivation; instructional design

TOPIC NUMBER: OSD01-CR14 **TITLE: Intelligent Assistant for Web-based Training Vignette Design**

MAIL ALL PROPOSALS TO:

Naval Air Warfare Center Training Systems Division
Attention: Bob Seltzer, Code 4.9.T
12350 Research Parkway
Orlando,FL 32826-3275
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OBJECTIVE: The purpose of this SBIR is to explore advanced concepts leading to the design and development of an intelligent tool to aid instructors in the creation of training vignettes for use in distance learning settings. The desired capabilities for this tool include, but are not limited to, a web-based interface that provides templates for the creation of training vignettes, guidance on the development of vignettes, and strategies for assessing and providing feedback after vignettes. The desired hardware capabilities for this tool include, but are not limited to, the compatibility with Department of Defense (DoD) distributed learning networks including behind and over the firewall models, with elements of the Shareable Content Object Reference Model (SCORM) and related standards, and learning objects based upon reasonable instructional model, and an open modular architecture.

DESCRIPTION: Implementing distance learning in the military is presenting many challenges. Two such challenges are designing courses that are engaging and can be completed during relatively short periods of time. Instructional designers are searching for alternative techniques to present information that actively engages users beyond electronic page turning courses. Providing trainees with training vignettes that pose realistic situations to which trainees must respond may be one such technique. Well-designed training vignettes can capitalize on effective training strategies such as concentrating on a well defined learning objective, offering a simulated yet realistic situation, focusing on behavioral responses and not just knowledge, measuring performance and providing feedback. Furthermore, trainees should be able to complete a single training vignette in less time than the typical one-hour lesson.

PHASE I: Explore alternative approaches, architectures, and feasibility concepts for the use of intelligent technology for the development of training vignettes. The contractor shall formulate detailed plans for 1) building a prototype training vignette tool and 2) testing its usefulness and cost-effectiveness. The plans for the prototype shall provide justification for the chosen content based upon an in-depth understanding of Navy, Marine Corps, Air Force, Army, or DoD DL requirements. It shall be capable of installation on an existing Department of Defense DL network (e.g., Navy ADL, Marine Net, Total Army Distance Learning Program, or the DoD ADL Co-Laboratory). The plans for prototype development shall also include methods to ensure compliance with DoD SCORM requirements.

PHASE II: Following the plans formulated during Phase I, the contractor shall provide a more detailed analysis of the specific context for development and implementation. The contractor shall then develop, test, and demonstrate the prototype training vignette development tool.

PHASE III: The contractor shall produce a technology demonstration based on the prototype system developed under Phase II. This technology demonstration will consist of creating and testing multiple training vignettes and formats will be evaluated at a DoD training facility.

COMMERCIAL POTENTIAL: There are many potential applications for developing training vignettes within and outside the military. Many commercial organizations are using DL to train their personnel in a wide variety of tasks. Once intelligent tools have been shown to improve the cost-effectiveness as well as enhance performance, they will quickly be incorporated into many DL applications.

KEY WORDS: distance learning; SCORM; training development, training vignette

TOPIC NUMBER: OSD01-CR15 **TITLE: Instructional System for Enhancing Seakeeping Cognitive Readiness and Decision-Making Skills**

KEY TECHNOLOGY AREA: TRAINING

MAIL ALL PROPOSALS TO: United States Special Operations Command
Attn: SOAL-KB/SBIR Program
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Phone number for express packages is 813-828-6512

OBJECTIVE: Due to their high performance, planing hull boat operations such as those performed by Naval Special Warfare (NSW) forces are more dangerous than operations with lower performance or larger maritime craft. These dangers are exacerbated if the helmsman does not understand the principles of negotiating wave conditions ("seakeeping") to avoid damage to the craft or crew. Seakeeping challenges take on an added dimension in military maritime operations because slowing down may not be an option given tight mission schedules and/or advancing threats. Seakeeping knowledge, skills, and abilities (KSAs) are generally acquired through years of on-the-job hands-on training experience. Crewmembers get injured and equipment is often damaged throughout the lengthy learning curve. The objectives of this topic are to: (1) identify the perceptual and cognitive KSAs that underlie seakeeping expertise; (2) develop instructional strategies to impart the perceptual and cognitive skills necessary to make accurate seakeeping judgements and decisions; (3) develop and demonstrate a prototype instructional system.

DESCRIPTION: Seakeeping expertise consists of acquired KSAs that involve integrated, interactive, and dynamic processing of information retrieved from both external (i.e., perceptual) and internal (i.e., cognitive) representations, through the interplay between perception and cognition. Mastery of the seakeeping task requires the honing of specific perceptual and cognitive (i.e., decision making) skills. Perceptual components of the seakeeping task consist of discriminating cues (perceptual invariants) that experienced helmsmen attend to in order to determine their seakeeping actions (e.g., wave height, periodicity, and direction of travel). These perceptual invariants must be recognized and interpreted to support effective seakeeping performance. Examples of cognitive decisions would be selecting the proper approach angle and speed, for a specific wave height, length, and direction. These judgements are made based on constant analysis of the perceptual cues that support the seakeeping task.

A comprehensive and detailed cognitive task analysis of the seakeeping task has not been located to date, and does not likely exist. This may be due in part to the non-verbal nature of the seakeeping task domain. That is, experts may be unaware of the perceptual/cognitive tasks he/she is performing (referred to as "meta-cognition") or may have difficulty verbalizing the stimulus/response contingencies of the seakeeping perception/action cycle. Thus, innovative knowledge elicitation approaches are necessary to identify principles of effective seakeeping that can serve as guidelines for instruction. Research is then needed to map innovative training interventions to the perceptual, cognitive, and psychomotor components of the seakeeping task, and training effectiveness must be empirically established.

Although some seakeeping strategies will vary as a function of craft dimensions, the perceptual invariants that give rise to effective seakeeping performance remain, for the most part, constant across platforms (e.g., various engines will sound differently as craft are launched through the air, but the informational value of the auditory cue remains the same). The instructional system should impart those seakeeping KSAs that are relevant across all types of small craft (i.e., less than 100 ft), but should also impart declarative knowledge about seakeeping strategies related to various hull lengths, speed, and wave height and periodicity.

PHASE I: Use knowledge elicitation techniques to perform a cognitive task analysis of the seakeeping task. Identify the knowledge, skills, abilities (KSA'S) that contribute to effective seakeeping performance. This task includes identification of the discriminating cues (perceptual invariants) and cognitive decisions that support effective seakeeping performance. Cognitive components should be in the form of "if __ then __" rules of thumb or principles of effective seakeeping. Validate seakeeping KSAs within a sample of subject Matter Experts (SMEs). Recommend standardized training methods, strategies, and techniques to impart the perceptual and cognitive skills necessary to make optimal seakeeping judgements and decisions. Develop a plan for a prototype instructional system that will impart seakeeping KSAs.

PHASE II: Devise seakeeping measures of effectiveness/measures of performance to be incorporated into a prototype seakeeping instructional system. Develop and demonstrate a prototype seakeeping KSA instructional system that incorporates performance measures and instructional features for recommended standardized training methods, strategies, and techniques to impart the perceptual and cognitive skills to optimize seakeeping judgements and decisions. Conduct a training effectiveness evaluation to determine which instructional features result in superior seakeeping performance using the prototype system.

PHASE III: Revise prototype seakeeping instructional system in accordance with sponsor's technical guidance. Transition the instructional system to military and other maritime training agencies.

COMMERCIAL POTENTIAL: An instructional system for training seakeeping KSAs would be useful to all DoD, non-DoD (e.g., USCG, Customs, and Federal Law Enforcement), and private maritime training institutions that impart seamanship skills. The instructional system would also be of interest to civilian boaters, particularly if it could be implemented on a personal computer. Other applications include a high-speed boat handling video game for the entertainment industry.

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KEY WORDS: seakeeping, seamanship, coxswainship, boat handling, shiphandling, sea conditions, sea state, marine effects, training

DUSD(S&T) Science And Technology Focus Area
Condition-Based Maintenance – Predictive Diagnostics

Maintenance comprises a major portion of the total operational cost for Department of Defense (DoD) weapons systems. Unnecessary or inappropriate maintenance contributes to inflated ownership costs and generally reduced readiness for deployable assets, while unscheduled maintenance requirements can be very costly and disruptive. Proper application of Condition-Based Maintenance (CBM) practices, which apply a methodology for the performance of maintenance only where there is objective evidence of need, as part of an overall maintenance effort can reduce operating and support (O&S) costs and work-hour requirements. Furthermore, maintenance decisions can be focused on those maintenance actions most needed to ensure safety and mission readiness. In doing so, CBM provides a means to manage the risk of mission-degrading failures.

Condition-Based Maintenance and Predictive Diagnostics are logical and appropriate successors to the very successful Reliability Centered Maintenance approach to equipment reliability and affordable operation. Ideally in condition-based maintenance, the operational health of specific components or a complex system is determined through sensors or a sensing system. This information then is used to make maintenance or operational usage decisions. Accurate and reliable predictors of current equipment health and the remaining useful life of equipment in service may be used to determine operating risk for the next operations or maintenance cycle, the most efficient scheduling of maintenance actions or inspections, or usage modifications to delay failure or repair. Prudent application of CBM has the potential to reduce operations and maintenance costs while stabilizing or increasing materiel readiness.

Advances in miniature sensors, life-prediction methodologies and real-time computation, signal processing and multi-sensor data fusion, and intelligent reasoning and control are providing a technological foundation for condition-based maintenance. Significant progress has been made in the rapid assessment of machinery condition through monitoring debris in lubricating oils and the condition of oils themselves, severity of hidden corrosion and general corrosiveness of environments, and acoustic and vibrational measures. Nevertheless, major challenges face the practical implementation of CBM technologies and operational practicality. Among these are the development and integration of self-powered or power-harvesting wireless micro-sensors capable of operating in high thermal or high mechanical load environments; models and methodologies that can predict health and expected life based on physical, mechanical, or other measurements; reliable methods to measure and predict corrosion degradation in unstable environments; predictive tools for advanced materials, materials systems, and structures and design concepts for in-service monitoring; and design tools to assist in selecting the most appropriate monitoring approach for a specific mechanical or electrical system.

The Condition-Based Maintenance Topics selected for this solicitation follow this section and are:

- OSD01-CBM01 Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating by Naval Air Systems Command
- OSD01-CBM02 "Smart" Machinery Spaces by Naval Sea Systems Command
- OSD01-CBM03 Fully Automated Bearing Residual Life Prognosis Wireless Sensor by Naval Sea Systems Command
- OSD01-CBM04 Fiber Optic Strain Field Measurement for Aging Aircraft by the Air Force Research Laboratory, WPAFB
- OSD01-CBM05 Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces by the Air Force Research Laboratory, WPAFB
- OSD01-CBM06 In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors by the Air Force Research Laboratory, WPAFB
- OSD01-CBM07 In-line Hydraulic Fluid Contamination Multi-Sensor by the Air Force Research Laboratory, WPAFB
- OSD01-CBM08 Fretting Fatigue Model by the Air Force Research Laboratory, WPAFB
- OSD01-CBM09 Reliability Algorithms for Corrosion Fatigue Assessments by the Air Force Research Laboratory, WPAFB
- OSD01-CBM10 Structural Component Substantiation Methodology by the Army Aviation and Missile Command
- OSD01-CBM11 Power Scavenging in a Cold, Dark Storage Environment by the Army Aviation and Missile Command
- OSD01-CBM12 Battery Optimized for Long Term Storage and Intermittent Use the Army Aviation and Missile Command
- OSD01-CBM13 Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy Related Systems by the Engineering Research and Development Center, Construction Engineering Research Laboratory
- OSD01-CBM14 Smart Coating / Sensor Blankets for Health Monitoring by the Engineering Research and Development Center, Construction Engineering Research Laboratory

TOPIC NUMBER: OSD01-CBM 01 **TITLE: Airframe Health Monitoring using Acoustic Emission Crack Detection with Bragg Grating**

Technology Area: Materials, NDE, Acoustic Emission

MAIL ALL PROPOSALS TO:
Alyssia Ogunyemi
Naval Air Systems Command
48066 Shaw Road
Bldg 2188, Rm 103B M/S 5
Patuxent River, MD 20670

OBJECTIVE: Enable effective and objective maintenance and repair decisions by identifying incipient cracking in aircraft structure. The methodology could use a wide area embedded acoustic emission system based upon a fiber optic (Bragg Grating) sensor for airframe health monitoring.

DESCRIPTION: The system to be developed consists of an imbedded fiber optic (Bragg Grating) sensor system capable of recognizing the presence of fatigue induced microcracks during the early stages of initiation and growth. The system would not require electrical conductors or leads but would consist entirely of optical fibers and a central processor/demodulation system. The microcracks generate ultrasonic acoustic strain waves when the composite is strained. With the initiation of a crack, stress releases an acoustic wave with frequencies in the 30 kHz to 500 kHz range. A repeatable acoustic wave for calibration can be generated by carefully breaking a pencil-lead against a test block. When a pencil lead breaks, there is a sudden release of stress energy where the pencil is touching the test block. Similarly, this optical sensor system to be developed will respond to frequencies in the 30 kHz range and monitor locations of fatigue induced by cracks that can be analyzed by computer software through normal and/or simulated operations.

PHASE I: During the Phase I of the program the contractor will develop a system incorporating fiber bragg gratings to detect emission pulses (of the order of 30 kilohertz) given off by cracks. The pulses are created using a RF burst from a continuous wave. The system has to be able to detect the emitted pulses immediately. The contractor will determine the key parameters that need to be optimized in order to enhance detection sensitivity and to make it ready for field use.

PHASE II: During the Phase II of the program the contractor will develop and test a prototype system capable of detecting acoustic emissions in a platform. The system will be capable of interrogating large areas by detecting and recording small emission signals via embedded fiber bragg gratings. All the software programs and controls should be accessible to the operator in an easy and friendly manner. All the key parameters that were identified for optimization in phase I will be incorporated in the prototype.

PHASE III: A system of this nature could be used in any DoD platform (F-18, F-14, etc.), since they all have critical structural components that require health monitoring. Significant cost savings could be achieved by using a wide area inspection system of this nature since real time health monitoring would decrease inspection costs by reducing unnecessary inspections and tear-downs for inspection.

COMMERCIAL POTENTIAL: Commercial aviation would benefit significantly from a system of this nature as well. Wide spread fatigue damage has been determined to be a major source of problem for commercial and military aviation.

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KEY WORDS: NDE, wide area, fatigue, cracks, acoustic emission, bragg gratings

TOPIC NUMBER: OSD01-CBM02 **TITLE:** ***"Smart" Machinery Spaces***

DOD Critical Technology: Condition Based Maintenance

MAIL ALL PROPOSALS TO: Ken Jacobs
Naval Sea Systems Command
2531 Jefferson Davis Highway
Arlington, VA 22242

OBJECTIVE: Develop methods and utilize technology to provide an onboard, remote wireless sensor network for single access point data retrieval and real-time monitoring of shipboard equipment to assist in Condition-Based Maintenance (CBM) and Remaining Useful Life (RUL) prediction.

DESCRIPTION: Current shipboard watch standing and plant equipment monitoring operations require the use of a "roving watch" to manually collect data from the various machinery spaces on a periodic basis. The Navy's long term objectives are to reduce manning, move to paperless systems and improve the quality of life. To support these objectives, the development of "smart" machinery spaces to collect, monitor and process key equipment data would be in concert with the Navy's end vision. These "smart" machinery spaces should use wireless technology, power harvesting methods, and a single access point data retrieval port. A wireless sensor network that extracts selected data will be a reliability-centered method to determine true equipment condition and provide an accurate indication of RUL. The envisioned method of data collection would be to utilize a wide array of wireless sensors mounted on or near the equipment that would extract desired data from existing sources. These capabilities would enable CBM and extend the useful life of equipment while reducing manpower.

PHASE I: Phase I would be a "proof of concept" and prototype system development consisting of the identification and application of a series of equipment sensors (monitoring temperature, pressure, current, voltage, etc.) tying into a network with a single point method of data retrieval. Predictive diagnostics and prognostic capabilities must be developed as part of the data processing software in order to determine the accurate status of the equipment health and provide a reliable RUL. The purpose of this Phase is to demonstrate the feasibility of using the wireless sensor technology network and processing software as an online real-time "snapshot" of the equipment health.

PHASE II: Build a demonstration system and successfully deploy it on representative system based either shipboard or at an appropriate shore based facility. This demonstration system should focus on a single subsystem and be simple to operate insuring a minimum of training or oversight. As part of the shipboard evaluation, the system accuracy should be compared against the current data collection methods. Further, develop the methods of power extraction (such as utilizing heat or vibration) to make the wireless sensor independent and self-sustaining. The Navy will provide access to a ship for prototype demonstration or suitable shore-based system at no cost to the SBIR contract.

PHASE III: Based upon the results of the evaluation and customer feedback, implement the system in a production environment. Obtain feedback from production personnel with regard to per unit costs and reliability. Make necessary revisions to the system and demonstrate its application to other shipboard systems or applications (such as combat system equipment). Investigate the application of the smart machinery space technology to include various commercial applications.

COMMERCIAL APPLICATIONS: With proper refinement and adaptation, this technology has commercial potential in various industries with equipment that must be monitored and subject to scheduled maintenance. Examples are oil refineries, natural gas facilities with remote pumping sites, power generation sites, oil platforms, barges and factories with co-generation facilities

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2) "Condition Based Maintenance: Machinery Diagnostics and Prognostics" Penn State University Applied Research Laboratory (PSU ARL) Accelerated Capabilities Initiative Program Review, Arlington VA, July 2000
3) "Prognostics Module Overview." By Mike Roemer, Impact Technologies LTD 125 Tech Park Drive, Rochester, NY 14623 WWW.IMPACT-TEK.COM

KEYWORDS: CBM, Online, Real-time, Reliability-Centered, Condition-Based, Remaining Useful Life Prediction, Predictive Diagnostics, Prognostics, Wireless technology

TOPIC NUMBER: OSD01-CBM03 **TITLE:** ***Fully Automated Bearing Residual Life Prognosis Wireless Sensor***

DoD Critical Technology: Sensors

MAIL ALL PROPOSALS TO: Ken Jacobs
Naval Sea Systems Command
2531 Jefferson Davis Highway
Arlington, VA 22242

OBJECTIVE: Develop methods to fully automate bearing condition assessment without the need for human interpretation using wireless sensor technology. The purpose would be to provide a consistent and accurate status of bearing condition and the Remaining Useful Life (RUL) directly from the sensor.

DESCRIPTION: Pre-mature rolling element bearing failure can occur in up to 10 percent or more of rotating machinery failure modes. Bearing condition prognosis is needed to determine current bearing status and life expectancy. Advances in sensor technology have resulted in "smart" sensors that not only detect a certain parameter but can now process and manipulate the data for prognostic use. Smart sensors permanently mounted on each bearing and networked to a machinery analysis tool will advance condition-directed decisions and reduce bearing failures and resulting machinery damage significantly. Integrating wireless technology into the system will reduce the sensor's vulnerability and provide for a variety of information pick up methods whether by handheld device or a central machinery control system. The wireless smart sensors could be self-reporting and networked to communicate with neighboring sensors for full integration with monitoring systems. The end result would be to allow human decision-makers to instantly know the health of key bearings to facilitate appropriate action.

PHASE I: Develop and describe the technical merit of the proposed wireless sensor system that would detect bearing status and RUL. The results of this phase shall be a working prototype of the system which demonstrates the data collection and analysis function of the sensor system. Specifically, this system will be capable of developing the ***statistical confidence accuracy*** of trouble-free life prognosis for the monitored bearings. The system should be applicable to shipboard equipment operating in an at-sea environment.

PHASE II: Build a demonstration system and successfully deploy it on representative system based either shipboard or at an appropriate shore based facility conforming to the Phase I prognostic methods. This demonstration system should focus on a single subsystem and be simple to operate insuring a minimum of training or oversight. The Navy will provide access to a ship for prototype demonstration or suitable shore-based system at no cost to the SBIR contract. The results of this phase shall be the successful demonstration of the system to monitor bearing condition and provide a useful RUL prediction on the monitored equipment.

PHASE III DUAL-USE COMMERCIALIZATION: It is anticipated that condition prognosis sensors will be manufactured for shipboard applications and industrial factory markets that utilize rotating machinery. They must be able to communicate with reliable and robust wireless networks.

COMMERCIAL POTENTIAL: It is predicted that the wireless sensor system would be an invaluable asset to any commercial industry using rotating machinery.

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KEYWORDS: condition; maintenance; prognosis; vibration; accelerometer; wireless; sensor

TOPIC NUMBER: OSD 01-CBM04 **TITLE: Fiber Optic Strain Field Measurement for Aging Aircraft**

DOD CRITICAL TECHNOLOGY: Materials/Processes

MAIL ALL PROPOSALS TO: Marvin Gale, AFRL/MLOP
2977 P St. Suite 13
Wright-Patterson AFB, OH 45433-7746

OBJECTIVE: Develop distributed fiber optic Bragg Grating based strain field measurement system.

DESCRIPTION: The measurement of strain on aerospace structures is important for monitoring the effects of vehicle aging. Although traditional foil strain gauge systems can be used they are burdened by the costs associated with multiple sensor leads as well as their susceptibility to EMI and harsh environments. Distributed fiber optic sensors offer tremendous reductions in weight, size, and lead count making these measurements cost effective. Fiber optic sensors are also known to provide immunity to EMI and harsh environments. Traditional lab and flight testing as well as advanced applications such as vehicle health management and wing shape morphing will also benefit.

The Air Force is seeking a fiber optic measurement system that will allow for high spatial resolution strain sensing along the length of a single mode fiber. This system should allow over 1000 measurements per fiber while simultaneously reducing the size, weight, and complexity of the sensor interface. Systems based on closely spaced Bragg grating arrays and scattering inherent in the fiber itself have recently been demonstrated.[1,2] The system should also allow for the measurement of temperature and other engineering parameters due to the ability to tailor the response of the grating array. Bragg grating based systems are absolute measurements which enable monitoring of strain state over the life of the vehicle. If embedded in future composite structures these systems can also provide information on composite cure and residual strains from manufacturing.

PHASE I: A program in this area should address the requirements and goals described above, and provide a feasibility demonstration of the concepts proposed. Viability of the technology will be quantified in terms of the breadth of needs addressed and demonstration of a viable approach. The phase one product for a successful effort is the feasibility concept design of 1000 strain/local environmental measurements on a single fiber.

PHASE II: The product from Phase I would be further developed into a prototype system intended to be compatible with current USAF aircraft inspection and maintenance philosophy. The product of this phase of the effort will need to be lab demonstration of the prototype concept design.

PHASE III DUAL-USE COMMERCIALIZATION: A fiber optic strain field measurement system of this nature would be a valuable tool for both commercial and military aircraft to effectively monitor the effects of aging over the life of an aircraft.

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1) Froggatt and Moore, "Distributed measurement of static strain in an optical fiber using multiple Bragg gratings at nominally equal wavelengths," Applied Optics, April 1, 1998.
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KEYWORDS: strain measurement, fiber optic, Braggs Grating

TOPIC NUMBER: OSD01-CBM05 TITLE: Development of an Evanescent Microwave Probe Scanner for Detecting and Assessing Corrosion Beneath Painted and/or Sealed Surfaces

DoD CRITICAL TECHNOLOGY: Materials and Processes

MAIL ALL PROPOSALS TO: Marvin Gale, AFRL/MLOP
2977 P. Street Suite 13
Wright-Patterson AFB, OH 45433-7746

OBJECTIVE: Design and manufacture an automated evanescent microwave probe scanner that field technicians can use as a non-destructive inspection tool for corrosion detection and assessment.

DESCRIPTION: It is a known fact that the USAF has a vast and extensive corrosion problem on its aging aircraft. Much of this corrosion is not visible to the naked eye or immediately detectable via current non-destructive inspection (NDI) techniques. For depot-level maintenance, these techniques include eddy current, ultrasound, dye penetrant, and X-ray. All of these NDI methods possess acceptable resolution and have their uses. However, there are also deleterious points to each. For example, X-ray must be accomplished during off-peak hours of maintenance to avoid exposing technicians to the harmful radiation, and interpreting the film may be considered an art form. For reliable results, eddy current and dye penetrant require comprehensive depainting and surface preparation of the structure to be evaluated, at the cost of time and money. Ultrasound can return ambiguous results to a novice NDI technician.

In contrast, evanescent microwave probes (EMP) have the ability to image subsurface features through poorly conducting materials, like paint, making EMP scanning a very viable option for detecting corrosion without depainting the area to be inspected. Evanescent microwave probes sense resonance frequency shift, power loss and DC level as a function of the conductivity, resistivity, and topology of a material. Because each of these factors in a metal can be changed locally by surface and near-surface defects, a change in measured parameters occurs when the probe passes over an area of corrosion. In research conducted by AFRL/MLMR on a 7075-T6 aluminum aircraft door, plots of the resonance frequency shift and power loss accurately demonstrated the existence of a corrosion pit measuring 100 microns (.1 mm) across. This pit had developed under several coats of paint and primer, making it not only invisible to the naked eye, but also undetectable with current NDI techniques. In fact, Zetec Corporation attempted to find this pit using their state-of-the-art laboratory eddy current systems, and failed. Steam cleaning followed by optical microscopy with dark field illumination finally brought the pit out. It is very likely that the corrosion would have grown unchallenged until serious structural damage had occurred. Therein lies the potential of evanescent microwave probe scanning for corrosion detection.

PHASE I: Given existing state-of-the-art evanescent microwave technology, conduct a feasibility demonstration to determine an optimum approach for employing evanescent microwave probes to detect and assess corrosion beneath painted and/or sealed surfaces. The concept scanning system must be portable. Candidate surfaces to be scanned include large curved areas, e.g. aircraft skins and panels.

PHASE II: 1) Develop a prototype evanescent microwave scanner that is ready for manufacturing optimization and testing; and 2) Demonstrate the effectiveness of the prototype through application to known AFRL-provided samples and USAF aircraft.

PHASE III: Commercial application is very broad, including DoD OEM's and their suppliers as well as the automotive industry. Application areas include the aforementioned corrosion detection, corrosion assessment, and the possible displacement of more subjective or costly non-destructive evaluation techniques.

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3) Robinson, "Third Harmonic Excitation Improves Resolution," *Photonics Spectra,* April 2001, p. 26.

KEYWORDS: evanescent microwaves; non-destructive evaluation/inspection; corrosion detection; aging aircraft; automated scanning

TOPIC NUMBER: OSD 01-CBM06 **TITLE: In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors**

DOD CRITICAL TECHNOLOGY: Materials/Processes

MAIL ALL PROPOSALS TO: Marvin Gale, AFRL/MLOP
2977 P St. Suite 13
Wright-Patterson AFB, OH 45433-7746

OBJECTIVE: Develop in-line monitoring system for early warning of impending failure of aircraft hydraulic pumps and motors

DESCRIPTION: The reliability of aircraft hydraulic pumps is critical for the safety of flight. To avoid catastrophic failures, the aircraft pumps/motors are replaced after a predetermined time interval. Sometimes, the pumps are replaced prematurely, and at other times catastrophic failures happen, thereby contaminating the entire hydraulic system. In some extreme cases, this catastrophic failure can result in loss of aircraft. In AFRL/MLBT pump tests, it has been observed that certain parameters develop unique characteristics when the pump is nearing failure. At this point the pump still has ~10% of its remaining useful life. If these parameters are captured electronically with an in-line health monitoring system, the pump/motor could be replaced before it failed catastrophically. Replacing the pumps/motors for cause would increase reliability, maintainability and readiness.

PHASE I: The concept's feasibility will be demonstrated using a bench-top health monitoring system consisting of pressure, flow, temperature and vibration sensors, and the necessary electronics. Synthetic electronic signals may be used to simulate the signal and signal-noise observed in the hydraulic pump tests as described in the references.

PHASE II: A miniature in-line pump health monitoring system, capable of recognizing the impending pump/motor failure, will be developed. The health of the pump/motor will be indicated by LEDs and/or stored in read-only memory that could be accessed by the maintenance staff. The system would be light weight, easy to use by the field level personnel, and fit in the high pressure lines of the aircraft hydraulic circuit. The system will be affordable and demonstrated in aircraft hydraulic pump tests.

PHASE III DUAL-USE COMMERCIALIZATION: The technology could be used in wide-ranging military and commercial applications. All military and civilian aircraft would benefit from an early warning of an impending hydraulic pump failure and the pumps would be replaced for cause, not after an arbitrary mean time between change. The same technology could be used in other industry wherever hydraulic pumps are used.

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KEYWORDS: hydraulic pumps, in-line health monitoring system, aircraft hydraulic fluid, aircraft hydraulic system, pump failure, sensors

TOPIC NUMBER: OSD 01-CBM07 **TITLE: In-line Hydraulic Fluid Contamination Multi-Sensor**

DOD CRITICAL TECHNOLOGY: Materials/Processes

MAIL ALL PROPOSALS TO: Marvin Gale, AFRL/MLOP
2977 P St. Suite 13
Wright-Patterson AFB, OH 45433-7746

OBJECTIVE: Develop an in-line contamination sensor for particulate, water and chlorinated solvents

DESCRIPTION: Hydraulic fluid contamination in aerospace hydraulic systems is currently determined by taking hydraulic fluid samples in bottles and sending them to laboratories for analysis. This is time consuming and the fluid samples can become contaminated during the sampling process, making the analysis invalid. The time delay between the sample being taken is so long that in most cases the aircraft or ground support equipment from which the sample is taken has been re-deployed or used. If the aircraft has hydraulic fluid that is severely contaminated, hydraulic system problems could occur in flight that could, in the

worst case scenario, result in an aircraft crash. If highly contaminated ground support equipment is used to service aircraft while the fluid analysis is being conducted, those aircraft hydraulic systems would also become contaminated. Both of these problems could be avoided by having an on-line contamination sensor available at the flight line. Another development that will require this technology is the new generation of ground support equipment, which is currently under development. This equipment will have a hydraulic fluid purification unit built in to assure that clean, contamination-free hydraulic fluid will be used to service Air Force aircraft. However, the technology described in this SBIR topic is required to tell the operator of the ground support equipment that the on-board purifier has adequately removed the contaminants from the hydraulic fluid to service the aircraft. In order for this technology to meet the requirements, it must be capable of determining the particulate contamination level, the water concentration and the chlorinated solvent concentration in hydraulic fluids in real time. In addition, the multi-sensor must be capable of having the desired control level of each contaminant individually set by the operator in such a manner that an indicator on the control panel will indicate when the fluid has been adequately purified, e.g., a red light turning to a green light for each individual contaminant. Simplicity of operation, calibration and maintenance shall be a high priority in the design of this multi-sensor. The sensor must have long term compatibility with MIL-PRF-83282 and MIL-PRF-87257, the two most widely used aerospace hydraulic fluids used by the Air Force. In order for this technology to reach its full potential, it must be affordable, lightweight and reliable

PHASE I: The anticipated results of the phase I effort are that the feasibility of the approach taken by the contractor has been proven to meet the objectives of the program. In addition, while a fully developed, actual device is not anticipated, a working prototype that demonstrates that the contractor's final device will be capable of determining the particulate, water and chlorinated solvent contamination levels in aerospace hydraulic fluids, MIL-PRF-83282 and MIL-PRF-87257 in-situ and real-time.

PHASE II: The anticipated results of the phase II effort are the complete development of the multi-sensor in its final form and demonstration that it is capable of all of the requirements stated in the objective. The probable long-term compatibility of the sensor with the hydraulic fluids will be demonstrated by accelerated materials compatibility testing of the sensor materials of construction with MIL-PRF-83282 and MIL-PRF-87257 hydraulic fluids at temperatures up to 135°C. A full-scale, simple-to-operate working unit will be delivered to the Air Force for testing at the completion of the contract.

PHASE III DUAL-USE COMMERCIALIZATION: This technology is directly applicable to the new generation ground support equipment being developed with built-in fluid purifiers. The rapid, on-site capability to assure the hydraulic fluid quality is essential to avoid significant delays in servicing the aircraft. Another application for this technology will be direct determination of the hydraulic fluid quality in the aircraft when used as a stand-alone device. This technology will also have tremendous application opportunities in the private sector. It will have direct applicability to commercial aircraft hydraulic fluid quality assessment and with minor modifications, if any, will have applicability to industrial hydraulic fluid quality assessment.

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1) Sharma S.K., Snyder, C.E., Jr. and Gschwender, L.J., Cecere, G.J., and Jenney, T.A., "Endurance Pump Tests with Fresh and Purified MIL-PRF-83282 Hydraulic Fluid," AFRL-ML-WP-TR-1999-4185, (1999)
2) Sharma, S.K., Snyder, C.E., Jr., Gschwender, L.J., Cecere, G.J., and Jenney, T., "Endurance Pump Tests with Fresh and Purified MIL-H-5606 Hydraulic Fluid," AFRL-ML-WP-1998-4211, (1998).

KEYWORDS: hydraulic fluid quality, in-line multi-sensor, fluid particulate contamination, fluid water contamination, fluid chlorinated solvent contamination.

TOPIC NUMBER: OSD01-CBM08 **TITLE: Fretting Fatigue Model**

DoD Critical Technology: Materials/Processes

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OBJECTIVE: Develop model for fretting fatigue that can be integrated into a corrosion fatigue model.

DESCRIPTION: Condition-based maintenance (CBM) has the potential to improve safety and readiness, and reduce by 30% operation & support costs, which accounts for about 65% of total life-cycle costs. CBM requires a method or tool to assess the severity of damage that is detected and estimate how fast it will grow in order to plan for maintenance. There are primarily four root causes, individually and concomitantly, for the development and growth of damage in aircraft: fatigue, corrosion, fretting,

and dynamic loads. Efforts are being made to abate the structural response to dynamic loads. An analytical model integrating the effects of corrosion, fatigue and fretting will be needed for an effective condition-based maintenance system. Work at AFRL to analytically model the interaction of fatigue and corrosion in developing structural damage using fracture mechanics has shown promise. Current models for fretting fatigue are not easily integrated into the framework of this corrosion fatigue model.

PHASE I: Develop framework for an analytical model of fretting fatigue that can be integrated with the corrosion fatigue framework. Outline how the fretting model can be implemented in an analysis tool and subsequently integrated into the corrosion fatigue framework. Determine critical data needed to develop a prototype model. Develop a validation and verification plan for the resulting prototype analysis tool.

PHASE II: Perform testing and analyses to obtain critical data for the prototype model development. Develop and document prototype analysis tool using the fretting fatigue model. Demonstrate the analysis tool. Determine the accuracy and reliability of the analysis tool as part of the validation and verification of the tool.

PHASE III DUAL-USE COMMERCIALIZATION: Fatigue analyses and corrosion control are performed in many industries as part of product design and maintenance: transportation (ground vehicle, train, aircraft, ship, space), power generation, chemical. The interaction of corrosion, fatigue and fretting has long been known in all these industries. However, the ability to analyze this interaction has been absent. A single analysis tool that would provide this capability would be attractive to all these industries. The potential for performing condition-based maintenance in the future should also be attractive.

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(1) Lichtenwaler, Peter F.; White, Edward V.; and Baumann, Erwin W.; "Information processing for aerospace structural health monitoring," *Proceedings of SPIE – the International Society for Optical Engineering, Smart Structures and Materials 1998 – Industrial and Commercial Applications of Smart Structures Technologies*, Vol. 3326, pp. 406-417, 1998.

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KEYWORDS: Aircraft Maintenance, Structural Integrity, Fatigue (Mechanics), Corrosion, Life Expectancy (Service Life), Aging (Materials)

TOPIC NUMBER: OSD01-CBM09 **TITLE: Reliability Algorithms for Corrosion Fatigue Assessments**

DoD Critical Technology: Materials/Processes

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OBJECTIVE: Develop algorithms to estimate the reliability of corrosion fatigue damage assessments and remaining life estimates.

DESCRIPTION: Condition-based maintenance (CBM) has the potential to improve safety and readiness, and reduce by 30% operation & support costs, which accounts for about 65% of total life-cycle costs. Implementing CBM requires algorithms that can: (1) assess corrosion fatigue damage; (2) predict how the damage will grow; and (3) provide a reliability measure for (1) and (2). Work at AFRL to analytically model the interaction of fatigue and corrosion in developing damage using fracture mechanics has shown promise in assessing corrosion fatigue damage and estimating remaining life. However, no reliability measure (or estimate of the confidence in the results) is constructed in this model. The reliability measure includes the reliability of the damage detection and the reliability of the prediction for how that damage will grow. A reliability measure is essential for CBM

using on-board diagnostics. It can also be used now by fleet managers who need to decide how soon maintenance or repairs need to be performed.

PHASE I: Identify the models and architecture of the algorithms that will be used to estimate the reliability of (1) corrosion and fatigue damage assessments and (2) damage growth and remaining life predictions. Determine critical data needed to implement the models in the algorithms. If data beyond what is in USAF databases, which is typically crack growth rates in corrosive environments, is needed to develop the models, a plan to obtain the needed data will need to be developed. This may include identifying other data sources. Identify how these algorithms can be integrated into the corrosion fatigue assessment framework. Develop a validation and verification plan for the prototype algorithms.

PHASE II: Obtain and analyze the data necessary to support the algorithm. Develop and demonstrate prototype algorithms. Validate and verify the prototype algorithms. Identify potential improvements and what data or work is needed to make the improvements.

PHASE III DUAL-USE COMMERCIALIZATION: Fatigue analyses are performed in many industries as part of product design and maintenance: transportation (ground vehicle, train, aircraft, ship, space), power generation, chemical. However, the numbers provided from this analysis are treated as deterministic with large safety factors (or uncertainty factors) used to account for scatter. A tool that would provide an estimate of the confidence in the results, and allow reducing the uncertainty factors, would be beneficial to all these industries. Integrating analysis of the effects of corrosion on structural life will make the tool more attractive. The potential for performing condition-based maintenance in the future should also be attractive.

REFERENCES:

(1) Lichtenwaler, Peter F.; White, Edward V.; and Baumann, Erwin W.; "Information processing for aerospace structural health monitoring," *Proceedings of SPIE – the International Society for Optical Engineering, Smart Structures and Materials 1998 – Industrial and Commercial Applications of Smart Structures Technologies*, Vol. 3326, pp. 406-417, 1998.

(2) McDowell, D.L.; Clayton, J.D.; and Bennett, V.P.; "Integrated diagnostic/prognostic tools for small cracks in structures," *Proceedings of the Institution of Mechanical Engineers, Part C – Journal of Mechanical Engineering Science*, Vol. 214, no. 9, pp. 1123-1140, 2000.

(3) Brooks, C.L.; Peeler, D.T.; Honeycutt, K.T.; and Prost-Domasky, S.; "Predictive Modeling for Corrosion Management: Modeling Fundamentals," *Proceedings of the Third Joint FAA/DoD/NASA Conference on Aging Aircraft (A00-1150101-01)*, Albuquerque, NM, 20-23 Sept. 1999. (Also available at: http://www.apesolutions.com/frm_link.htm).

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KEYWORDS: Aircraft Maintenance, Structural Integrity, Fatigue (Mechanics), Corrosion, Life Expectancy (Service Life), Aging (Materials)

TOPIC NUMBER: OSD01-CBM10 **TITLE: Structural Component Substantiation Methodology**

DoD Critical Technology: Air Platforms

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OBJECTIVE: Develop a system methodology, utilizing data gathered by aircraft health and usage monitoring systems, to identify fatigue lives of structural aircraft components.

DESCRIPTION: The U.S. Army aviation fleet is comprised of various helicopter and fixed wing assets. Helicopters such as the AH-64 Apache and UH-60 Black Hawk comprise a large portion of the aviation inventory along with older OH-58 Kiowa and UH-1 Huey aircraft. Current practice is to utilize a "safe life" design approach with regards to these aircraft's critical dynamic components. The method, which uses a Miner's Linear Cumulative Damage* compilation of component fatigue strength, flight test loads, and customer's usage profile, does not quantify structural reliability either on a absolute basis or on a relative basis.(1). This process mandates that a structural and/or dynamic component be assigned a calculated retirement time, i.e. replacement, based on an expected operating flight spectrum. Aircraft components are replaced when aircraft flight hours

reach a designated number regardless of the actual flight usage spectrum, which is never fully understood. This philosophy, while insuring an excellent flight safety record, has the potential to incur substantial operational and support costs, which may be unnecessary. Another drawback to this method is that the major helicopter manufacturers have their own variation of "safe-life" analyses and thus there is no general consensus on retirement times.(2) Several programs are currently on going directed towards identifying actual usage spectrums for U.S. Army helicopters. These Health and Usage Monitoring Systems (HUMS) employ a variety of sensors installed on the aircraft. These sensors include position and force sensors, accelerometers, G-meters, thermocouples, pressure transducers, etc. These sensors provide information on critical dynamic component issues such as rotor track and balance, and engine/turbine operation. Information recorded during aircraft flight can also be used to identify actual flight spectrums of these aircraft. What is needed is a methodology to utilize this "regime recognition" information to substantiate the structural reliability of the aircraft.

PHASE I: Develop a system methodology to utilize the HUMS data to identify maintenance actions for structural aircraft components. Data will be provided by the Government to quantify the selected methodology. The developed methodology should provide the same structural reliability as the existing safe life methodology.

PHASE II: Improve and enhance the methodology as required to identify fatigue lives of structural components. Demonstrate the methodology on sub-scale test articles. Develop a model of the component replacement/maintenance process to include field unit maintenance actions, logistics and supply actions, and parts procurement actions. Identify the changes necessary to the current model to fully utilize actual recorded usage data in a conditioned based maintenance system. Draw up guidelines for condition-based maintenance of articles selected.

PHASE III/COMMERCIAL POTENTIAL: Condition based maintenance plans and procedures are expected to have many commercial applications in the aviation (military and civilian), automotive, maritime, and various other industries. The main product or end item expected to result from this research will be a system methodology (in others words a computer based model or algorithm) which utilizes data/information already being obtained through health and usage monitoring systems. On-board systems (sensors and computer hardware/software) designed to monitor, diagnose, and evaluate structural component lives has the potential to improve safety, maintainability, and reliability and also reduce costs associated with airframes, ships, domestic power generators, etc. Any industry concerned with structural components that undergo repeated and/or cyclic loading can benefit from the technology that results from this SBIR program.

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3) Minor, M.A., "Cumulative Damage in Fatigue", J. Appl. Mech., vol. 12, Trans. ASME vol. 67, 1945 pp. A159-A164

TOPIC NUMBER: OSD01-CBM11 **TITLE: Power Scavenging in a Cold, Dark Storage Environment.**

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OBJECTIVE: To provide research in power scavenging in a cold, dark, and static storage environment for use in health monitoring systems.

DESCRIPTION: The Army is in the process of fielding an environmental monitoring system to report environmental parameters from inside a missile container. A requirement for this health monitoring system is that it is invisible to the soldier. A serious challenge presents itself in the power requirements of such a system. The life of a missile can last 10 years and possibly even 20 years. To make this health monitoring system last as long as the munitions it is collecting data on, some sort of power scavenging technique will be required. One of the most difficult places to do this type of scavenging would be in bunker storage. The environment there has fairly cool temperatures, no light, and immobile.

PHASE I: Phase one of this research would be identifying existing techniques of power scavenging and relating them to their ideal environments that they supply power in, identifying environments that make power scavenging difficult, and make recommendations on how to scavenge power in these environments.

PHASE II: Phase II shall consist of prototyping power scavenging techniques in the cold, dark, static environments. Also the contractor will provide recommendations for bunker modifications to allow for sufficient power scavenging.

PHASE III DUAL USE COMMERCIALIZATION: Power scavenging techniques in cold dark storage areas could revolutionize the electronic market, in the same way solar power scavenging did. This technology could be used in conjunction with solar power cells and be able to provide charging ability during both night ant day.

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1) Morita, Yasushi; Fujisawa, Toru; Tani, Tatsuo, "Moment performance of photovoltaic/thermal hybrid panel (Numerical analysis and exergetic evaluation)", Electrical Engineering in Japan (English translation of Denki Gakkai Ronbunshi) [Electr Eng Jpn], vol. 133, no. 2, pp. 43-51, Nov 2000

2) Wascheul, F; Cocquerelle, JL; Armelin, A, "Novel strategy to control battery recharging, complying with EN61000.3.2", IEEE INT SYMP IND ELECTRON, IEEE, PISCATAWAY, NJ, (USA), 1997, vol. 2, pp.507-510,

3) Wang, Xianming; Yasukawa, Eiki; Mori, Shoichiro, "Inhibition of anodic corrosion of aluminum cathode current collector on recharging in lithium imide electrolytes", Electrochimica Acta [Electrochim Acta], vol. 45, no. 17, pp.2688-2684, 2000

Key Words: power scavenging, rechargeable, environment,

TOPIC NUMBER: OSD01-CBM12 **TITLE: Battery Optimized for Long Term Storage and Intermittent Use**

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OBJECTIVE: To provide research in small, durable (environmental extremes), long life, low voltage batteries for the use in health monitoring applications.

DESCRIPTION: The Army is in the process of fielding an environmental monitoring system to report environmental parameters from inside a missile container. A requirement for this health monitoring system is that it is invisible to the soldier. This requirement creates limitations to the health monitoring system (i.e. weight, size, dimensions, maintainability, etc.). The strict requirements of the health monitoring system eliminate several commercially available batteries from consideration, as they are currently configured. The health monitoring system is in need of a battery that is optimized for the following:

1) Long life (10+ years) with intermittent usage
2) Small form factor (dimensions must be small to fit into monitored entity)
3) Environmental extremes (ranges must be greater than the entity it is monitoring)
4) Voltage and current requirements (Will be dependent on hardware, slightly flexible, power management techniques will be used to prolong life)
5) Low cost

PHASE I: Phase I will consist of researching into battery types and configurations and identify the strengths and weaknesses of each scenario. From this data, trade off studies will be performed to determine what battery characteristics (i.e. battery chemistry, form, size, etc.) are preferred for the health monitoring system. Also recommendations will be made as to what battery or combination of different batteries will best suit the system needs, and what characteristics may provide a superior performance battery. (i.e. The battery chemistry from battery A in the geometric form of battery B.)

PHASE II: Phase II would consist of developing prototypes of the battery characteristics specified in Phase I and would also include validation testing of these prototypes.

PHASE III: DUAL USE COMMERCIALIZATION: A battery with the above desired characteristics (form, size, low voltage, extended life) could be a highly marketable item to electronic and MEMS manufacturing organizations. This battery technology would also be very useful on the data-collectors biologists use to track marine animals.

REFERENCES:

1) Park, YJ; Park, KS; Kim, JG; Kim, MK; Kim, HG; Chung, HT.; "Characterization of tin oxide/LiMn sub (2)0 sub (4) thin-film cell", Journal of Power Sources [J Power Sources], vol. 88, no. 0, pp.250-254, 2000

2) Banner, Julie A; Barnes, James A; Winchester, Clinton S.; "Continuing challenges in lithium battery development", IEEE Aerospace and Electronic Systems Magazine [IEEE Aerosp Electron Mag], vol. 15, no. 5, pp 31-33, 2000

3) Mantell, C. L., "Batteries and energy systems / C.L. Mantell": 2nd Edition, McGraw-Hill; New York, New York c1983

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5) Marinez, Carlos; Drori, Yossi; Cianco, Joe., "Components and techniques for managing smart batteries", Electronic Engineering (London) [Electron Eng London], vol. 72, no. 879, 5 ppp, 2000

Key Words: batteries, low voltage, extended battery life, form, size

TOPIC #: OSD01-CBM13 **TITLE: Non-Destructive Life Prediction and Component Interaction Fault Tree for Energy-Related Systems**

DoD CRITICAL TECHNOLOGY: Environmental Quality/Civil Engineering

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OBJECTIVE: Develop a non-destructive testing (NDT) sensor network that can determine the condition of complex energy-related systems that operate in a corrosive and/or direct buried environment. The advanced sensor network would provide the data for predicting material properties and remaining life of energy system components such as distribution piping, boilers, chillers, and associated mechanical equipment. The diverse sensor network will include hardware to generate the necessary signals to detect mechanical properties such as strain and electrochemical properties such as corrosion scaling. Software will also be developed for processing the received signals to yield quantitative measurements of remaining life.

Key considerations are that the developed sensor array (1) must be usable in-situ, limited to soil surface access, (2) must not create any environmental problems or interfere with mechanical properties, (3) must produce quantitative results related to material properties and corrosivity, and (4) must interface with software (algorithms) that contain a comprehensive fault tree indicating component interactions and all possible failure pathways.

DESCRIPTION: Energy-related systems designed to provide heating and cooling contain various components such as boilers, chillers, cooling towers, associated mechanical equipment and distribution networks (direct, buried, or entrenched) that contain numbers of segments (pipes, etc.) and nodal intersection points. Currently, managers of energy systems maintain these systems by identifying components needing repair and fixing them as necessary. Manufacturers recommended maintenance schedules have not always been reliable guides for maintaining individual components, where accelerated degradation of a component is caused by incorrect operation and not by its own deficiencies. With the development of Engineered Management Systems (EMS), Army energy managers gained access to a set of repeatable inspection-based tools to help optimize system operation and prioritize maintenance requirements. What is needed is an NDT sensor array and software that can determine the remaining life of each component and the overall energy system. The components of an energy system are so closely interrelated that the failure of one component frequently degrades or overstresses the entire system. For example, if an expansion slip joint in a piping network seizes, damaging mechanical stresses may be transferred to segments or nodes hundreds of feet away. Various NDT technologies, such as acoustics, electromagnetics, and electrochemical (AC impedance) offer a good basis for a solution because their signals are affected directly by the material properties or the geometry of the material in which they are traveling, leading to quantitative measurements. Further, these techniques are environmentally friendly, are theoretically capable of

traveling long distances in engineered systems, and can thoroughly interrogate a structure's integrity. One of the basic problems that has to be solved during the development of the required NDT sensor array is that the wavelength or signal energy of the penetrating signal can become larger than the phenomenon being measured. Another basic problem to be resolved is the lack of understanding of the interactions of acoustics and electromagnetic waves with the corrosion product. These relationships must be understood to be able to infer certain material properties, such as strength and/or remaining life of the material.

The data from the sensor array would then interface with existing algorithms that assign a condition index (CI) to each component, combine the various CI's, and apply them to the appropriate fault tree to determine an overall CI for the energy system.

PHASE I: Select and justify the most appropriate NDT technology to permit in-situ single-sided measurements on energy systems. Select the most appropriate mathematical models to predict remaining life based upon details in signals modulated by corrosion products or loss of material properties. Investigate optimal wave shapes and signal energies to produce the greatest signal change when interacting with corrosion products. Develop prototype sensor array design and component interaction fault tree for a heating and cooling system.

PHASE II: Produce a prototype NDT sensor array for a heating and cooling system based upon the prototype design developed in Phase I. Interface the NDT sensor array with the component fault tree and test the functional measurement capability of the sensor array on model structures containing controlled defects. Refine the hardware, sensors, and component fault tree to obtain accurate life prediction. Demonstrate the operation of the refined field NDT sensor array and software on at least one heating and cooling system, with the specific objective of proving that useful engineering data can be obtained in the field under real operating conditions.

PHASE III: The military and commercial applications include district heating and cooling systems, decentralized heating and cooling systems.

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(1) Marsh, C.P., B.A. Temple, and A. Kim, *Condition Prediction Model and Component Interaction Fault Tree for Heat Distribution Systems*, ERDC/CERL TR-01-35 (Engineer Research and Development Center/Construction Engineering Research Laboratory, April 2001)
(2) Marsh, C.P. and T.R. Laughton, *Boiling Manhole Heat-Loss Calculations*, USACERL TR 98/062, ADA350373 (ERDC/CERL, June 1998).

KEYWORDS: fault tree; heat distribution systems; corrosion; sensors; non-destructive testing; life prediction; piping

TOPIC NUMBER: OSD-CBM14   TITLE: Smart Coatings / Sensor Blankets for Health Monitoring

DoD CRITICAL TECHNOLOGY: Environmental Quality/Civil Engineering

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OBJECTIVE: To develop and test smart coatings that contain embedded sensors or other technology to monitor the health of a coated metal structure and detect and quantify coating degradation and substrate corrosion. An alternative approach is a blanket containing a sensor array that can be wrapped around a structure.

DESCRIPTION: Coating failure is a primary cause of corrosion of steel equipment and structures at Army installations and in the field. Inspection of coatings is primarily accomplished visually which is labor intensive and is not feasible in inaccessible areas of critical components without disassembly. In addition, the inspection is only qualitative and requires significant coating degradation and substrate corrosion to be detectable. Smart coatings with embedded sensors or sensor blankets would allow quantitative inspection of critical components on a periodic or continuous basis and would warn of coating degradation prior to significant deterioration of the structure. Development and laboratory testing of such smart coatings (or alternatively, sensor blankets) is needed to enable condition-based maintenance (CBM) and predictive analysis of critical structures. The resulting

coatings will be validated and used on steel equipment at Army facilities.

PHASE I: Develop and test coatings with embedded sensors (or alternatively, sensor array blankets) that monitor corrosion of the actual coated structure, i.e., not corrosion of the sensor itself. Develop procedures to locate coating damage using an array of sensors. Demonstrate the feasibility to track coating degradation using paints, appliqués, or other coatings.

PHASE II: Perform development and laboratory testing of smart coatings (or alternatively, sensor blankets) which can be used on critical steel equipment used in corrosive environments. Develop associated health monitoring and predictive diagnostics procedures. Demonstrate and validate smart coatings (or alternatively, sensor blankets). The contractor may request the use of Army equipment or facilities to conduct the demonstration, at no cost to the SBIR contract.

PHASE III: This technology also represents a high payoff potential for the monitoring and maintenance of critical civilian structures, such as chemical reaction vessels, that are exposed to corrosive environments. Possible industries include chemical processing, pharmaceutical, microelectronics, pulp and paper, and aviation. Additional military applications include storage tanks, pipelines, aging aircraft, and Navy ships.

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1. Davis, G.D., C.M. Dacres, and L.A. Krebs, "*In-Situ* Corrosion Sensor for Coating Testing and Screening," *Materials Performance* **39**(2), 46 (2000).
2. Davis, G.D., C.M. Dacres, and L.A. Krebs, "EIS-Based *In-Situ* Sensor for the Early Detection of Coating Degradation and Substrate Corrosion," *Corrosion2000,* Paper 275 (National Association of Corrosion Engineers, Houston, TX, 2000).

KEYWORDS: corrosion; coatings; degradation; sensors; condition-based maintenance; predictive diagnostics

OSD DEPUTY UNDER SECRETARY of DEFENSE (S&T) / DEFENSE HEALTH PROGRAM BIOMEDICAL TECHNOLOGY FOCUS AREA

The Jointly Sponsored Deputy Under Secretary of Defense (S&T) and Defense Health Program Office have established this focus area to explore biomedical technology research issues. The biomedical technology area is focused to yield essential technology in support of the DoD mission to provide health support and services to U.S. Armed Forces. Most national and international medical S&T investment is focused on public health problems of the general population. Military medical S&T is concerned with developing technologies in order to preserve combatants' health and optimal mission capabilities despite extraordinary battle and non-battle threats to their well being. Preservation of individual health and well being sustains warfighting capabilities. The Biomedical Reliance Panel is included within the overarching structure of the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee, which provides joint coordination and cooperation to ensure synergy across all biomedical programs.

We have chosen the following topics and Service Laboratory Executive Agents to manage the SBIR topics in this technology area:

- OSD01-DHP01 Development of a Vaccine for the Treatment and/or Prevention of Cancer by US Army Medical Research Acquisition Activity
- OSD01-DHP02 Development Of A Serum Based Biomarker For The Detection Of Cancer by US Army Medical Research Acquisition Activity
- OSD01-DHP03 Lightweight Trauma Module by US Army Medical Research Acquisition Activity
- OSD01-DHP04 Photoactivated Chemical for Tissue Bonding by US Army Medical Research Acquisition Activity
- OSD01-DHP05 New Biosensors for Real-Time Terrestrial Toxicity Monitoring by US Army Medical Research Acquisition Activity
- OSD01-DHP06 Rapid Diagnostics for Detection of Respiratory Pathogens by the Naval Health Research Center
- OSD01-DHP07 Biomarkers of Musculoskeletal Soft-Tissue Injury by the Naval Health Research Center
- OSD01-DHP08 Production Of Purified Recombinant Proteins For Development Of Vaccines Of Military Importance by the Naval Medical Research Center
- OSD01-DHP09 Reduction of Motion Side Effects and After Effects by the Special Operations Command

Descriptions of the biomedical topics are on the following pages.

U.S. ARMY MEDICAL RESEARCH ACQUISITION ACTIVITY TOPICS

TOPIC NUMBER OSD01-DHP01 **TITLE: Development Of A Vaccine For The Treatment And/Or Prevention Of Cancer**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Design, develop and manufacture safe and effective vaccine(s) for the prevention and treatment of cancer.

DESCRIPTION: Currently available treatments have limited efficacy for a substantial proportion of patients with prostate, breast and ovarian cancer. In addition, there are few preventative procedures that have been demonstrated to be effective to reduce the occurrence of cancer for patients at high risk. In the United States, it is estimated that 31,900 men will die from prostate cancer, and 54,800 women will die from breast or ovarian cancer this year (1). The development of vaccine based therapy for the prevention and treatment of cancer would complement existing forms of therapy for these diseases. This approach could also benefit patients whose disease cannot be treated by conventional therapies, such as those that cannot be resected surgically, or have spread to multiple sites. A potential vaccine could employ a number of different approaches, including basis on tumor cells, carbohydrates, peptides and heat-shock proteins, DNA-based vaccination and the use of recombinant bacteria and viruses to deliver antigens or the DNA coding for antigens to target cells (2,3). The incorporation of dendritic cell technology in vaccine development also is an important advance (4). These leukocytes can be engineered to overexpress the antigen of interest, stimulating the immune system to induce protective and therapeutic immunity in animals (5). These novel vaccine technologies could be used to develop preventative and treatment modalities against a number of diseases, including HIV, malaria, hepatitis, H. Pylori, as well as cancer (6,7). The potential vaccine could have the ability to (a) safely induce the immune response in cancer patients against antigens associated with tumors and (b) have the potential to result in regression of an established tumor. A potent therapeutic vaccine could have the additional benefit of preventing the development of cancer in patients with high risk, or preventing recurrence in patients after initial treatment and remission.

PHASE I: The objective of Phase I is to develop the initial formulation of the vaccine that would be considered to have the potential for specific immunogenicity in patients with cancer. This would include data that demonstrates that the chosen antigen is specific for cancer cells, or elicits an immune response against cancer cells.

PHASE II: The objective of Phase II is to (a) develop sufficient resources needed for the production of a vaccine, (b) the clinical formulation of the vaccine and (c) conduct Phase I clinical trials in patients to determine the safety and immunogenicity of the vaccine.

PHASE III DUAL USE APPLICATIONS: . This phase would involve clinical trials of the vaccine for Food and Drug Administration marketability. This technology may permit the development of better vaccines for military personnel and their dependents as well as civilian populations who are at high risk for cancer or recurrence of cancer. In addition, this technology may permit development of better vaccines, and their delivery, for military personnel who are deployed to geographical regions with exotic endemic disease as well as both military personnel and civilian populations exposed to biological agents.

KEYWORDS: Vaccine delivery, Therapeutics, Cancer,

REFERENCES:
(1) American Cancer Society. 2000. Cancer Facts & Figures 2000.
(2) Chamberlain, R.S., 1999. Prospects for the therapeutic use of anticancer vaccines. Drugs, 57:309-325.
(3) Restifo, N.P., Ying, H., Hwang, L., Leitner, W.W. 2000. The promise of nucleic acid vaccines. Gene Ther. 7: 89-92.
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(5) Timmerman, J.M. 1999. Dendritic cell vaccines for cancer immunotherapy. Annu. Rev. Med. 50: 507-529.
(6) Romano, G., Michell, P., Pacilio, C., Giordano, A. 2000. Latest developments in gene transfer technology: Achievements, perspectives and controversies over therapeutic applications. Stem Cells. 18: 19-39
(7) Liang, T.J., Rehermann, B., Seeff, L.B., Hoofnagle, J.H. 2000. Pathogenesis, natural history, treatment and prevention of hepatitis C. Ann Intern Med. 132: 296-305.

TOPIC NUMBER OSD01-DHP02 **TITLE: Development Of A Serum Based Biomarker For The Detection Of Cancer**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: Develop, design, and construct innovative screening modalities and associated materials to detect and/or diagnose pre-cancerous and cancerous lesions using serum based biomarker assays.

DESCRIPTION: The development of screening biomarkers to detect and/or diagnose pre-cancerous conditions, as well as cancerous lesions related to breast cancer, prostate cancer, and ovarian cancer, are needed to enhance diagnosis and treatment. The biomarkers currently utilized for ovarian and prostate cancer have sensitivities as low as 30% to 40% (1). It is recognized that PSA has limited value in androgen independent prostate cancer (2). Similarly, CA125 has been used as a serum marker for the detection and monitoring of ovarian cancer, but results have been disappointing (3). Better screening biomarkers are needed to enhance diagnostic capabilities. Patient care would be enhanced if cancer could be detected earlier in the course of the disease. Additionally, the course of therapy could be modified, potentially increasing effectiveness, if immediate assessment of efficacy using a serum based marker could be utilized. It is intended that the biomarkers extend the utility of the tests beyond those currently available, such as those currently used for prostate cancer (PSA) and ovarian cancer(CA125). The overall goal of this solicitation is to develop standardized tests that can act as reliable predictors and indicators of cancer development, effectiveness of treatment, and/or recurrence. The program is seeking the identification of biomarkers that are sensitive and specific for breast, prostate ovarian cancer, as well as other cancers.

PHASE I: The objective of Phase I is to identify and outline the feasibility and applicability of the putative biomarker(s). This will include data showing the detectability of the biomarker in tissue or cell-line samples with potential to be detected in easily collected body fluids, such as blood, saliva, or urine.

PHASE II: The objective of Phase II is to test the potential of the biomarker and the assay in cancer patients. This phase will include the development of an assay for the biomarker and testing with clinical samples to determine sensitivity and specificity. The goals for sensitivity and specificity are 95% or greater.

PHASE III DUAL USE APPLICATIONS: The development of very sensitive and highly specific biomarker assays that would accurately detect, diagnose, and monitor cancer, promises to be a tool for the clinician to detect cancer earlier, and customize care for individual patients. This phase would involve clinical trials of the screening modality for Food and Drug Administration marketability. Early diagnosis of breast, prostate and ovarian cancer, is needed to enhance the survival of military personnel and DOD beneficiaries from these diseases and to reduce health care costs.

KEYWORDS: Biomarker development, Cancer detection, Biotechnology

REFERENCES:

(1) DeVita, V.T., Hellman, S., Rosenberg, S.A., (eds). 1997. Cancer, Principles & Practice of Oncology. Lippincott-Raven, Pub.
(2) Kim, J., Logothetis, C.J. 1999. Serologic tumor markers, clinical biology and therapy of prostatic carcinoma. Urol Clin North Am, 26:281-290.
(3) Meyer, T., Rustin, G.J. 2000. Role of tumor markers in monitoring epithelial ovarian cancer. Br J Cancer. 82:1535-1538.

TOPIC NUMBER OSD01-DHP03 **TITLE: Lightweight Trauma Module**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: To develop a lightweight module that will attach to a standard military stretcher for the treatment of trauma patients.

DESCRIPTION: A major goal for this topic is a module weight of 50 pounds or less. It also should not exceed a depth of 1 foot, and a width no greater than the standard NATO stretcher (22 inches). The capability goals of the trauma module include vital signs monitoring, for blood pressure, pulse rate, cardiac rhythm, temperature, blood oxygen saturation, respiratory rate, expired tidal volume. In addition, the module shall have: a defibrillator capable of "hands off" operation; ventilator that does not require oxygen or compressed air to function; EKG machine; infusion capability; surgical suction device with both positive and intermittent capability; oxygen delivery device; and ability to support existing anesthesia device. The power requirements are standard 115 volts (50-60 hertz) and 11-30 volts DC with a minimum 30-minute electrical power back up system and provisions for external power.

PHASE I: Investigate engineering feasibility of the concept.

PHASE II: Design and fabricate a prototype for demonstration and evaluation by the military. Refine this design into a final pre-production prototype. Conduct appropriate testing and prepare for submittal to FDA for approval.

PHASE III: Develop production equipment and field a low rate of initial production followed by mass production for both the military and commercial markets.

DUAL USE: This device will also have applications in the commercial market where there are far more trauma cases from auto accidents, gun incidents etc.

KEYWORDS: trauma, life support, transport, emergency, medical care, combat trauma

REFERENCES:
(1) Military Medicine, Volume 160, January 1995
(2) Handbook on Ground Forces Attrition in Modern Warfare, Dupuny TN
(3) Battle Casualties, Springfield IL, Charles Thomas, 1952

TOPIC NUMBER OSD01-DHP04 **TITLE: Photoactivated Chemical for Tissue Bonding**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: To develop a novel photoactivated tissue adhesive for potential application in the repair of skin and blood vessels.

DESCRIPTION: Currently, wound closure requires suturing, which is time-consumptive for the combat surgeon. In order to decrease surgical time, laser welding has been extensively used to repair tissues such as skin, blood vessels and nerve. Laser welding, however, depends on attainment of high temperatures that denature collagen; such temperatures may also produce thermal damage to surrounding tissue. Recent results suggest that athermal tissue bonding to produce chemically-induced collagen crosslinking might be better suited to achieve repair, while also being less damaging to surrounding tissue. This topic seeks to develop a novel photoactivated tissue adhesive for repair of skin and blood vessels.

PHASE I: Identify a novel photoactivated crosslinking substance in vitro and determine whether this substance can produce bonds in tissues ex vivo. Requirements for such a tissue bonding substance include: 1) adhesion to collagen-containing tissues; 2) free radical production (which causes collagen crosslinking) on exposure to light energy insufficient to heat tissue; 3) collagen crosslinking occurring under conditions encountered within in vivo tissues (i.e., body temperature and under a "wet" environment); 4) no, or limited cytotoxicity; and, 5) the resulting bond should be at least as strong and provide tissue regrowth and healing at least comparable to the current standard of care (i.e., conventional suturing techniques). At the end of Phase I, in vitro and ex vivo data should be provided that demonstrates conceptual feasibility of the proposed substance in meeting the above requirements.

PHASE II: Demonstrate tissue bonding in a realistic environment, namely, in in vivo models of skin and blood vessel injury. The criteria for acceptance of tissue bonding as an appropriate adhesive strategy are: 1) the tensile strength of the repaired tissue is at least as good as that produced by conventional suturing techniques; 2) the total time of tissue repair accomplished using bonding techniques is at least that required for conventional suturing, if not shorter; and, 3) the inflammation and fibrosis

produced at the repair site is less than or equal to that produced by conventional suturing techniques. The desired end product of Phase II is completion of an in vivo demonstration of a prototype substance that meets the above criteria.

PHASE III DUAL USE: A photoactivated tissue bonding substance could be used in a wide range of civilian medical applications to replace conventional suturing.

KEYWORDS: Tissue bonding, tissue repair, collagen crosslinking, laser, light energy

REFERENCES:

(1) Bass, LS and MR Treat. Laser tissue welding: A comprehensive review of current and future clinical applications. Lasers Surg. Med. 17:315-349, 1995

(2) Mulroy, L, J Kim, I Wu, P Scharper, SA Melki, DT Azar, RW Redmond, and IE Kochevar. Photochemical keratodesmos (PKD) for repair of lamellar corneal incisions. Invest Ophthalmol Vis Sci. 41:3335-40, 2000.

TOPIC NUMBER OSD01-DHP05 **TITLE: New Biosensors for Real-Time Terrestrial Toxicity Monitoring**

DOD TECHNOLOGY AREA: Biomedical

ARMY MEDICAL PROPOSALS SHOULD BE MAILED TO: US Army Medical Research Acquisition Activity
MCMR-AAU (Herman Willis)
820 Chandler Street
Ft. Detrick, MD 21702-5014

OBJECTIVE: The objective is to develop and integrate advanced biosensor technology in a field-deployable platform to provide continuous, real-time monitoring for developing toxic conditions in air. The platform will assess the possible impairment of our forces that may encounter toxic chemicals in the air during training or deployment.

DESCRIPTION: The U.S. Army Center for Environmental Health Research (USACEHR), in conducting research in the field of deployment toxicology, seeks new methods for real-time assessment of continuously-monitored biological endpoints to define the toxicity of environmental media.. Although many chemical or biochemical sensors are being developed to detect exposure to individual toxic materials, this effort focuses on using real-time biological responses to identify toxic hazards that may be due to unsuspected materials or the joint action of chemical mixtures and that can complement chemical sensor technology. Technologies are sought for incorporation into a sensor platform deployed in the environment to provide continuous, real-time monitoring information. Biosensors may range from cellular or sub-cellular systems to tissue-based biosensors or whole organisms. Important characteristics of the biosensor data for providing useful toxicity data are listed below. It is anticipated that more than one biosensor approach may be required to achieve these goals.

1. Sensitivity to a broad range of toxicants in air and rapid response (less than 10 minutes). Through appropriate biosensor selection and interpretation, provide real-time differential responses to various classes of toxic chemicals (toxic industrial chemicals/materials and military-unique substances).
2. Minimal interference caused by variations in environmental parameters such as temperature, humidity, etc.
3. Suitability for continuous, on-line data acquisition and analyses.
4. Capability for integration in a field-deployable platform.

PHASE I: Conduct research to demonstrate the efficacy of one or more individual biosensors for continuous, real-time toxicity detection. The biosensor(s) will be original or will represent significant extensions, applications, or improvements over published methods. Experimentation must show that the biosensor(s) exhibit the above characteristics. Proof of concept will be accomplished through at least one toxic exposure monitoring event identification using the biosensor(s).

PHASE II: Expand Phase I research to include additional biosensor(s) that will provide an array of biological indicators to accurately and continuously monitor developing toxic conditions in real time and to improve the system's ability to define the mode of action of applied toxicants. Integrate the biosensors into a field-deployable platform. Specific chemical sensors should be added, as required, to augment the biosensors. Real-time, continuous data from the platform will be provided in a format suitable for real-time off-platform transmission and remote analysis. The sensitivity and response characteristics of the proposed suite of biosensors will be evaluated through laboratory tests with various classes of chemicals including, but not limited to, pesticides, organic solvents, and military-unique substances.

PHASE III DUAL-USE APPLICATION: The field-deployable platform will be integrated with other similar platforms, creating a network to provide early warning of developing toxic conditions in air and their potential hazard to troops. A variety of field applications are possible, including assessment of environmental hazards to troops pre-, during, and post-deployment. Field tests will apply platform/network under variable environmental conditions. The new platforms will increase the reliability and usefulness of current biomonitoring technology by identifying potential toxic chemical hazards to troops. Also, the platforms may be used to monitor and assess the environmental impacts of military site activities and the compliance of such activities with regulatory requirements. Civilian applications include "air shed" monitoring in urban, agricultural, and industrial areas where exposures to toxic chemicals are an issue. USACEHR would consider providing non-SBIR funding after successful completion of Phase II.

REFERENCES:

(1) J.P. Obusek, "Warfighter Physiological Status Monitoring," Army RD&A, July-August, 10-12 (1999).
(2) G.M. Murray, A.L. Jenkins, A. Bzhelyansky, and O.M. Uy, "Molecularly Imprinted Polymers for the Selective Sequestering and Sensing of Ions," Johns Hopkins APL Technical Digest, 18(4), 464-471 (1997).
(3) J. White and J.S. Kauer, "Rapid Analyte Recognition in a Device Based on Optical Sensors and the Olfactory System," Analytical Chemistry. 68(13), 2191-2202 (1996).

KEYWORDS: Biosensors, Real-time monitoring, Continuous monitoring, Terrestrial toxicity

NAVAL MEDICAL RESEARCH ACTIVITY TOPICS

TOPIC NUMBER OSD01-DHP06 **TITLE: Rapid Diagnostics for Detection of Respiratory Pathogens**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:

Commanding Officer
Naval Health Research Center
Attn: LCDR Margaret Ryan, MC, USN
Code 25
PO Box 85122
San Diego, CA 92186-5122

OBJECTIVE: Develop simple point-of-care rapid diagnostic tools for the detection of emerging respiratory pathogens

DESCRIPTION: Epidemics of acute respiratory infection are common among military personnel. This has particularly been true of crowded training populations and large newly mobilized populations where sudden mixing and close contact of personnel from disparate regions of the United States, and numerous physical stressors, can quickly lead to morbidity affecting thousands of personnel. The etiology of the epidemics vary with season and geographical site but often include adenoviruses, influenza viruses, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Streptococcus pneumoniae*, *Bordetella pertussis*, and *Streptococcus pyogenes*. As many of these pathogens cause adult infections, which have similar clinical presentations, clinicians and epidemiologists need rapid point-of-care diagnostic tools to discern epidemic etiology such that appropriate interventions may be made. Current testing such as that involving culture, serology and polymerase chain reaction, when available, often takes too long to be clinically relevant or is too technically complex for military field medical personnel to employ.

PHASE I: Development of feasibility and concept design. Using laboratory strains, simple, point-of-care, rapid diagnostic tools should be developed to identify emerging strains of militarily important respiratory pathogens such as: adenovirus type 4, adenovirus type 7, *Mycoplasma pneumonia*, *Chlamydia pneumoniae*, *Bordetella pertussis*, Respiratory syncytial virus, parainfluenza viruses 1, 2, and 3, and emerging strains of influenza A such as H5N1. Such rapid test technology should be simple such that a medical person with only a high school education may effectively use the tests. Similarly, the rapid test should be robust and not require complex medical equipment such that it may be taken into the military field environment without threat of compromising test accuracy.

PHASE II: Prototype testing. After laboratory design, prototypic tests should next be performed in human subjects in a clinical setting. Culture, serology, and / or other molecular methods should validate such testing.

PHASE III: Military field testing. Once successful in trial, prototype tests should be field-tested in military operational settings by military medical personnel and again validated against culture, serology, and/or other molecular methods. Results should be shared with civilian public health professionals since it is likely that such tests would have significant commercial value in the civilian setting in addition to their value in the military environment.

REFERENCES:

(1) Gray GC, Callahan JD, Hawksworth AW, Fisher CA, Gaydos JC. Respiratory Disease Among U.S. Military Personnel: Strategies to Counter Emerging Threats. *Emerg Infect Dis* 1999; 5:379-87.

(2) Gray GC, Goswami PR, Malasig MD, Hawksworth AW, Trump DH, Ryan MA, Schnurr DP for the Adenovirus Surveillance Group. Adult Adenovirus Infections: Loss of Orphaned Vaccines Precipitates Military Respiratory Disease Epidemics. *Clin Infect Dis*, 2000;31:663-70.

(3) Jansen DL, Gray GC, Putnam SD, Lynn F, Meade BD. Evaluation of pertussis in US Marine Corps Trainees. *Clin Infect Dis* 1997;25:1099-107.

KEYWORDS: respiratory infections; rapid detection; epidemiology; military medicine

TOPIC NUMBER OSD01-DHP07 **TITLE: Biomarkers of Musculoskeletal Soft- Tissue Injury**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:
Commanding Officer
Naval Health Research Center
ATTN: LCDR Kujawa
P.O. Box 85122
San Diego, CA 92186-5122

OBJECTIVE: Identify, and develop field tests for, valid biomarkers of musculoskeletal soft-tissue injury.

DESCRIPTION: During the Persian Gulf War conflict, 35% of all injuries (3726 of 10,526) were musculoskeletal injuries. Of these, 1177 injuries were soft-tissue injuries. Soft-tissue injuries are not apparent on traditional x-rays. The standard diagnostic method for soft-tissue injuries is magnetic resonance imaging, which is relatively expensive and not available in the field. Inability to diagnose soft-tissue injuries in the theater of operations necessitated the evacuation of 65% (769 of 1177)[1].of casualties with soft-tissue injury. Evacuation of these casualties not only delayed diagnosis and treatment, it also resulted in a considerable additional cost in terms of logistics and replacement personnel. The capability of diagnosing these injuries in the theater of operations would result in earlier treatment of the injury and a decrease in the logistical costs of evacuation for injuries treatable on-site. The validation of specific biomarkers of musculoskeletal injury and the development of rapid, reliable field tests for those biomarkers[2], would result in earlier treatment of wounded personnel and savings resulting from decreased evacuation costs.

PHASE I: A number of biomarkers of muscle, collagen, and other soft-tissue injuries have been identified. Most of these markers are measured from serum and are relatively non-specific. In addition, biomarkers present in urine and/or saliva need to be screened. Urine and saliva have obvious advantages in ease and non-invasiveness of sample collection. Phase I will be a concept design to determine the feasibility of development of simple, reliable, and relatively inexpensive bioassays for markers of soft-tissue injury. These tests should be easy to perform by technicians under military field conditions.

PHASE II: Phase II will be a demonstration of prototype bioassays. Demonstration will include validity and reliability of the bioassays.

PHASE III DUAL-USE COMMERCIALIZATION: Soft-tissue injuries are a problem not just during armed conflicts, but during regular training of military personnel. Some occupations (e.g., Special Warfare personnel), are particularly likely to suffer a soft-tissue injury at some point during their career. An inexpensive, rapid test to diagnose these injuries would result in considerable savings, both in terms of money and time away from duty. In the commercial world, soft-tissue injuries are a major source of workmen's comp claims, yet may be difficult, expensive, and time-consuming to diagnose. An inexpensive test that could definitively prove that an injury exists would be of benefit to employers and employees alike.

REFERENCES:

(1) Truax, AL, PC Vijay, AK Chacko, and DM Gonzalez. 1997. Incidence and methods of diagnosis of musculoskeletal injuries incurred in Operations Desert Shield and Desert Storm. Invest. Rad. 32:169-173.
(2) Saxton, JM. 2000. A review of current literature on physiological tests and soft tissue biomarkers applicable to work-related upper limb disorders. Occup. Med. 50:121-130.

KEYWORDS: Biomarkers; soft-tissue injury; diagnostic test.

TOPIC NUMBER OSD01-DHP08 **TITLE: Production of Purified Recombinant Proteins for Development of Vaccines of Military Importance.**

DOD TECHNOLOGY AREA: Biomedical; DUSD(S&T) Focus Area: Force Health Protection

MAIL ALL PROPOSALS TO:
Commanding Officer, Naval Medical Research Center
Attn: CAPT D.J. Carucci, USN
503 Robert Grant Avenue (room 3A40)
Silver Spring, MD 20910-7500

OBJECTIVE: To express, produce and purify recombinant proteins for the development of vaccines of military importance.

DESCRIPTION: A major priority of the biomedical research conducted by the Department of Defense biomedical research is to develop effective vaccines for the prevention of emerging and re-emerging infectious diseases threats, and against biological warfare agents. We propose to use malaria as a model system to establish the capability for expressing and purifying properly folded recombinant proteins for vaccine development since, as compared to developing vaccines against viruses and bacteria, the development of effective malaria vaccines is complicated by the complexity of the parasite (multiple stage life cycle, large number of proteins expressed at each stage, variability of target antigens) and the complexity of the human host's response to the infection. Developing effective and sustainable vaccines against complex pathogens such as malaria may require the use of multiple immunogens and of multiple vaccine delivery systems depending upon which arms of the immune system are to be activated. Malaria vaccine development has focused on developing subunit vaccines that duplicate the protective immunity induced by immunization with radiation attenuated sporozoites (T cell mediated), or by lifelong exposure to natural infection (antibody mediated) (1,2). For both approaches, a major priority is the production of recombinant proteins that can be used to induce protective immune responses in vivo (either as recombinant protein prime/boost or DNA prime/recombinant protein boost vaccination strategies) (3, 4), or to evaluate vaccine-induced T cell and antibody immune responses in vitro. Accordingly, this topic requests development of efficient methods for expressing, purifying and producing recombinant *Plasmodium falciparum* proteins for use as in vitro antigens and in vivo immunogens. The production of such proteins is complicated by the enormous difficulties in expressing intact *Plasmodium* proteins as compared with expressing bacterial or viral proteins, by the requirement for pure protein preparations free of contaminants which would induce nonspecific responses, and by the requirement for large-scale GMP-grade production of such proteins for use as immunogens in vivo. Therefore, critical aspects which must be met by competing companies include: (I) documented experience with expressing, producing and purifying *Plasmodium falciparum* proteins, including proteins which have been documented to have biological activity in vitro and in vivo; (ii) documented experience with manufacture under Good Manufacturing Practices (GMP) of recombinant proteins that have been used in human clinical trials; and (iii) demonstrated experience producing therapeutic proteins under GMP conditions with yields greater than 100 mg/liter.

PHASE I: In order to demonstrate the feasibility of the concept and design, express *Plasmodium falciparum* recombinant proteins, fully characterize the expressed proteins, and demonstrate in vitro expression of the proteins, antigenicity in vitro, and immunogenicity in mice and/or non-human primates.

PHASE II: Produce and purify recombinant *Plasmodium falciparum* proteins under Good Laboratory Practices (GLP) conditions, fully characterize the proteins, and demonstrate antigenicity and immunogenicity and in some cases protective efficacy in non-human primates. Finalize prototype that can be transitioned to clinical testing in Phase III and eventual commercialization.

PHASE III: Develop and demonstrate plans for transitioning to Good Manufacturing Practices (GMP) production, conducting pre-clinical safety studies, and submitting investigational new drug applications (IND) to the FDA. Manufacture under Good Manufacturing Conditions (GMP) conditions, conduct pre-clinical safety and immunogenicity studies in support of investigational new drug (IND) applications to the Food and Drug Administration (FDA), prepare IND, submit IND, conduct Phase I/II safety, immunogenicity, and protective efficacy studies in human volunteers, and perform regulatory oversight of such studies.

DUAL USE-COMMERCIALIZATION: The recombinant proteins produced in response to this topic have the potential to be developed as a vaccine against malaria, either as a recombinant protein in adjuvant approach or as a component of a prime/boost vaccine strategy. A successful malaria vaccine will eliminate the need for chemoprophylaxis in deployed troops and will prevent the degradation of fighting capabilities due to malaria infection. In addition, such a vaccine would protect civilian travelers and residents of malaria endemic areas. It is anticipated that the vaccine technologies developed will be applicable to a variety of traditional and emerging infectious diseases.

REFERENCES:

(1) Hoffman SL. Malaria vaccine development: a multi-immune response approach. Washington, D.C.: American Society for Microbiology, 1996.

(2) Miller LH, Hoffman SL. Research toward vaccines against malaria. Nat.Med. 1998; 4:520-524.

(3) Stoute JA, Slaoui M, Heppner DG, Momin P, Kester KE, Desmons P, et al. A preliminary evaluation of a recombinant circumsporozoite protein vaccine against *Plasmodium falciparum* malaria. N.Engl.J.Med. 1997; 336:86-91.

(4) Wang B, Doolan DL, Le TP, Hedstrom RC, Coonan KM, Charoenvit Y, et al. Induction of antigen-specific cytotoxic T lymphocytes in humans by a malaria DNA vaccine. Science 1998; 282:476-480.

KEYWORDS: Proteins; Vaccines; Biotechnology; Immunology; Malaria; Infectious Diseases

TOPIC NUMBER OSD01-DHP09 **TITLE: Reduction of Motion Side Effects and After Effects**

MAIL ALL PROPOSALS TO: United States Special Operations Command
Attn: SOAL-KB/SBIR Program
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621
Phone number for express packages is 813-828-6512

TECHNOLOGY AREAS: Human Systems, Cognitive Readiness

OBJECTIVE: Develop methods and devices for reducing side-effects due to motion.

DESCRIPTION: Special Operations Forces are often required to deploy troops by sea and air in platforms designed to optimize war-fighting characteristics such as speed, endurance, survivability and agility. Such craft can induce significant motion side effects in the deployment force. These debilitating side effects are exasperated by relatively poor visual cues due to restricted visibility quarters and, frequently, nighttime or inclement weather deployments. Side effects include nausea, vomiting, cognitive degradation (e.g., reduced reaction times, poor mental acuity and agility), postural disorientation and drowsiness that can last for several hours and that can negatively impact the physical and cognitive mission readiness of the forces upon their arrival in the operation area. To an appreciable degree, these side effects are induced by the discordance of the visual environment with the sensed, motion environment. Similar situations can arise in personnel operating in, hovercraft, amphibious and armored vehicles where personnel encounter relatively violent motion in enclosed spaces with poor visual cueing, and even simulators or manned/unmanned platforms using remote viewing sensors.

The currently used regimen of meclizine is not always effective and there are concerns about sedation with this medication. Transderm scopolamine is another option but is more expensive and also may be associated with possible adverse effects. There are physical interventions available to address motion sickness too, including accupressure, electro-nerve stimulation, and artificial horizon optics, but these have their own side effects and operational limitations.

The intent of the SBIR is to consider that technology has moved on and supports a re-look at this problem. This SBIR seeks to develop and apply a physical or pharmaceutical intervention that provides relief or prevention from motion sickness without physical or cognitive side effects, and operational limitations.

PHASE I: The primary vectors leading to side effects and after effects induced by small maritime craft and aircraft have been well studied by DoD, NASA, and civilian transportation organizations. Considering the design and operating profile of SOF maritime and air platforms, and based on a literature search of motion sickness studies, develop a device or family of devices and/or identify FDA-approved medical interventions that will prevent/reduce these effects. Build a brass-board prototype and/or obtain medical interventions and demonstrate their efficacy at a laboratory level. Finally, develop design requirements and an experimental protocol supporting further exploration of the device/pharmaceuticals' capabilities.

PHASE II: Build several candidate devices as designed in Phase I, and/or obtain necessary quantities of medicinal interventions. Execute the experimental protocol, which shall include at least one series of tests conducted at sea either on a Naval Special Warfare Craft or on a similar craft. Quantitatively evaluate the effectiveness of each device in cognitive and physical readiness terms.

PHASE III DUAL USE OPPORTUNITIES: Effective and non-debilitating motion sickness interventions are critical to military, commercial, and leisure activities such as diving, driving, aircraft/boat piloting, space travel and parachute operations.

REFERENCES:

(1) Burkicohen J. Soja NN. Longridge T. "Simulator platform motion - the need revisited." International Journal of Aviation Psychology. 8(3):293-317, 1998.

(2) DiZio, P., Lackner, J.R. "Spatial orientation, adaptation and motion sickness in real and virtual environments." Presence, 1(3):319-328, 1992.

(3) Kennedy RS. Lanham DS. Drexler JM. Massey CJ. Lilienthal MG. "A comparison of cybersickness incidences, symptom profiles, measurement techniques, and suggestions for further research." Presence- Teleoperators & Virtual Environments. 6(6):638-644, 1997 Dec.

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KEYWORDS: Motion Simulation; Motion Sickness, Motion Side Effects, Motion After Effects, Vertigo

OSD Deputy Under Secretary of Defense (S&T)/ Defense Health Program (DHP) Information Technology Topics for Military Health System (MHS)

The Jointly Sponsored Deputy Under Secretary of Defense (S&T) and Defense Health Program Office have established this Small Business Innovative Research (SBIR) program focus area to do applied research on Information Technology (IT) issues directly supporting the Military Health System (MHS). The MHS has approximately 80 major Military Treatment Facilities, 500 clinics, 160,000 healthcare personnel, and 8.3 million eligible beneficiaries. This health system results in approximately 900,000 outpatient visits and 10,000 hospital admissions per week.

The objective of these topics is to support the Military Health System optimization plan that includes the areas of: 1) Access to care, 2) Provision of care, 3) Manage the business and 4) Population health management.

On the following pages are the SBIR topics in this technology area, which are managed by Telemedicine and Advanced Technology Research Center, which is a part of Army Medical Research and Material Command at Ft. Detrick, Maryland:

1. OSD01-DHP10 Technology Enhanced Human Interface to the Computerized Patient Record
2. OSD01-DHP11 Cognitive Patient-Clinician Encounter Model
3. OSD01-DHP12 Health Information Data Mining

TOPIC NUMBER: OSD01-DHP10 **TITLE: Technology Enhanced Human Interface to the Computerized Patient Record**

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL ALL PROPOSALS TO:

MCMR-AT
Attn: Dan Richardson
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012
301-619-4059 Email: Richardson@tatrc.org

OBJECTIVES: Technology enhanced human interface to the military computerized patient record in the context of an automated data collection and medical documentation methodology with associated technologies to optimize the physician patient interaction during medical encounters.

DESCRIPTION: The goal of MHS is for military physicians to spend not more than 15 minutes with each patient during routine outpatient appointments. Current requirements for administrative and medical data collection for the MHS Military Treatment Facilities (MTFs), and collection of information for diagnosis and treatment by the provider from sources other than the patient significantly detract from the time the physician has to directly interact with the patient for examination, diagnosis, treatment, and consultation. Research needs to be performed on methodologies and technologies to enable necessary data collection without impacting patient/physician interaction. A program is underway to develop a Computerized Patient Record (CPR). MTF health care providers currently use a combination of handwritten and computerized data entry techniques to capture and document the clinical encounter. The desktop workstations currently employed to capture this information seem to hinder the productivity as the Military strives to deliver effective and efficient healthcare. A method is needed to reduce the footprint of the computer workstation and integrate several capabilities into an efficient and practical hand-held devices and potentially wireless environment. In order to improve work processes the new automation system needs to address capabilities, such as hand held devices with

A Clinic and/or provider role-specific practice management system with Cached appointed patients with Patient Encounter Modules (PEMs) for:

a) Patient demographics and immunizations
b) Patient active meds/allergies and drug-drug interactions
c) Patient problem list and alerts
d) Local registration, appointing & scheduling
e) Order entry, status and results retrieval
f) Voice transcription & speech recognition
g) Encounter Notes using natural language processing (NLP)
h) Coding for billing based on NLP auto processing
i) XML compliant web enabled open architecture approach
j) Biometric identification and login

PHASE I: This phase focuses on developing methodologies and technological concepts to enable the collection of necessary data without impacting patient/physician personal-interaction. The proposed research should examine how to provide integrated computer-based health care information capabilities into efficient and practical hand-held devices that utilize potentially wireless and secure information technologies, and can be used throughout the military continuum of care, from forward deployed to fixed medical facility environments. The researcher will do a literature search; define health information integration, patient safety, and security requirements; define and analyze technology approaches; and prepare a preliminary technical and operational design for application of candidate technologies to patient/physician interaction within the entire military continuum of care.

PHASE II: The researcher will demonstrate construct a prototype system test bed to analyze and test the recommended/selected technological concepts and methodologies and then continue to examine additional scenarios and Patient Encounter Modules (PEMs). The prototype should demonstrate how technology enhanced human interface to the military computerized patient record in the context of an automated data collection and medical documentation methodology with associated technologies can optimize the physician patient interaction during medical encounters.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these

would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

REFERENCES:

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KEYWORDS: Information Technology, military, Healthcare, CPR, Computerized Patient Record, PDA, hand held devices.

TOPIC NUMBER: OSD01-DHP11 **TITLE: Cognitive Patient-Clinician Encounter Model**

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL ALL PROPOSALS TO:

MCMR-AT
Attn: Dan Richardson
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012
301-619-4059 Richardson@tatrc.org

OBJECTIVES: Investigate knowledge management technologies to develop a physician and patient encounter model to provide problem-oriented user-definable information in the appropriate form and at the appropriate time.

DESCRIPTION: SBIR proposals should suggest novel ways to display complex integrated clinical data. Not all clinicians have working for them, a supporting staff member whose job focus is to gather the appropriate patient data in a packet prior to the appointment. Programs exist in the area of clinical trials that look for trends, graph labs with graphical representation of high and low limits and arrows coded with intervention; but they have not been applied to support normal, non research oriented, clinical practice.

In the case of a physician patient encounter, the physician user of an integrated medical information system should be able to identify the specific information needed for the encounter, how it is to be displayed, at what time during the encounter in order to conform to his/her own view of the problem. An example of a first step solution to this problem is a web browser user interface which can be dynamically configured by the user to display the information needed in the format desired; the next step would be for the computer to learn from experience with each user, and subsequently predict the desired views of each type of problem for each user. In order to be responsive, the "intelligent" user interface must also be connected to an efficient back-end processor that is able to retrieve, analyze, and format appropriate information from diverse sources, such as records of medical history and physical examinations, ancillary test results, imagery and other patient information to support a specific medical encounter. Once retrieved and processed, the information should be displayed in such a manner as to help the physician to quickly formulate or improve the physician's big-picture view (i.e., "Gestalt") of the patient within the context of specific symptoms and problems. The user interface should be web-based to support enterprise wide access to the information.

A patient is a set of ongoing problems that are interrelated. When you go to take your car in for your 50,000 miles check up would you go back if they only repaired but did no maintenance? A patient should be seen as a whole, not a part isolated and out of context. Until we can present a Gestalt vision of a patient that a physician can look at a glance, technologists will be doing nothing innovative; but just presenting incomplete information within a new platform. Each medical specialty has specific packets of information they need to perform their job, but the generalist, the internist or family practice practitioner must see it all in a glance to truly manage the patient and take care of "repairs". With each encounter the clinician should be presented with a snapshot of data related to the patient's specific problems so the clinician can quickly address the current problem, within the context of the whole patient and take care of maintenance simultaneously. The problem list with all integrated data is a start.

As an example, within a cardiovascular patient view, should be a chronology of interventions and findings (tabular or graphical display) of echocardiograms (date and abnormal findings), EKGs (e.g., date and summary, linked to views), stress tests, multi-gated nuclear medicine imaging for ejection fraction and wall motion abnormalities (MUGA), blood pressures graphed with intervention/meds, coronary artery bypass surgery(s) (CABG date and vessels), abnormal physical examinations (e.g., pedal edema), and related risks (e.g. cholesterol, values graphed with intervention; diabetes mellitus (DM) with medication list, A1C (hemoglobin marker of glucose levels), albuminuria (albumin in urine), foot exam, eye exam dates, and significant findings; exercise program and compliance information, diet consultations and program compliance information, alcohol and cigarette usage, medication compliance score (obtained from pharmacy record already in the ancillary clinical health care system database) and laboratory results. When this information is presented in a single screen, with an optimal single view, the clinician will immediately have a broad view of a physiological system (e.g., cardiovascular) and therefore be able to address subproblems in the context of the whole instead of just the part. We need a better way to present clinical data to ensure it is complete.

A template can work for a quick problem, but one should also be able to quickly annotate the problem list with the necessary information as needed, therefore viewing the patient as a whole and his specific complaint as a subset of that whole patient. In that way, a clinician can, within a 15-20 minute encounter, care for a specific problem (e.g., bronchitis) and also evaluate the whole patient and with a directed history address what the clinicians training and experience is telling them is the most important problem and not just what the patient or medic or secretary has recorded as the chief complaint.

PHASE I: This phase focuses on developing methodologies and technological concepts to enable the presentation of necessary data without negatively impacting patient/physician interactions. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches; and prepare a preliminary technical and operational design for application of candidate technologies to patient/physician interaction within the entire military continuum of care from the forward deployed to fixed medical center environments.

PHASE II: The researcher will construct a prototype system test bed and enlarge the range of existing scenarios. The prototype should demonstrate how knowledge management technologies to develop a physician and patient encounter model could provide problem-oriented user-definable information in the appropriate form and at the appropriate time to increase the quality of the physician patient interaction during medical encounters.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

REFERENCES:

(1) Baker DW, Parker RM, Williams MV, Pitkin K, Parikh NS, Coates W, Imara M. The health care experience of patients with low literacy. Arch Fam Med 1996;5:329-34.

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KEYWORDS: Information Technology, military, Healthcare, CHCS, CHCS II, Pharmacy, Laboratory, Radiology, scheduling, patient encounter

TOPIC NUMBER: OSD01-DHP12 **TITLE: Health Information Data Mining**

DOD CRITICAL TECHNOLOGY: Information Technology – Military Health System

MAIL ALL PROPOSALS TO:

MCMR-AT
Attn: Dan Richardson
Building 1054, Patchel St.
Fort Detrick, Maryland 21702-5012
301-619-4059
EMAIL: Richardson@tatrc.org

OBJECTIVES: To investigate technologies and methodologies and to develop approaches and computational tools for performing data mining that is capable of supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data.

DESCRIPTION: One of the primary uses would be to allow healthcare researchers to perform data analysis to determine the effects of certain illnesses on individuals total careers and develop accession standards to allow for the best possible screening of entry recruits. Other aspects of Data Mining of the clinical data stored in the Military Health System (MHS) Data Repository (MDR) would allow for comparative results of treatment outcomes and procedures at different health care facilities within the overall MHS systems. Algorithms could be developed to provide early detection and notification of possible biological or chemical exposures of personnel by relating observed symptoms against the time history of duty locations. The government will provide access to appropriate data.

The possibilities of improving medical care via the use of information collected from data that are and will be in the MHS Data Repository databases are tremendous. Data Mining on an individual's health information will allow the provider a detailed medical history, master problem analysis, drug reactions, and health care trends in a matter of seconds instead of minutes or hours if assessed from the current system of paper and electronic records. It will also allow for improved business practices in the MHS.

For non-clinical information, the tools should gather, integrate, aggregate, and display staffing, financial, facility characteristics and other business data to characterize the performance of all aspects of MHS Operations. This includes integration of both direct care and purchased care. Significant increases in the scope of non-clinical data in the MDR include all staffing, manpower and personnel; facility characteristics; and data to support oversight and management of contracted Managed Care Support Contracts (MCSCs), provided by non MHS organizations. This is the business side of the fully evolved and fully populated MHS data repository.

The Data Mining tools might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

PHASE I: This phase focuses on doing literature search, requirements refinement, scope definition, alternatives analysis and preliminary business case development. The researcher will do a literature search, define health information integration requirements, define and analyze technology approaches and prepare a preliminary technical and operational design for application of candidate data mining technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care from the primary care outpatient clinics to the fixed medical center environments. Phase I should also demonstrate, to the maximum extent possible, proof-of-feasibility of the approach to be prototyped in the subsequent Phase II.

PHASE II: The researcher would construct a prototype system test bed of data mining tools and similar candidate technologies with potential for supporting epidemiological research and comparative analysis on vast arrays of clinical and non-clinical data within the entire military continuum of care that might utilize natural language or other artificial intelligence technique and user-friendly interfaces to eliminate any burden on the user/provider to interact with the software. The tool must be robust enough to support simple data search and retrievals as well as queries involving complex data analyses and inductive capabilities.

PHASE III DUAL USE COMMERCIALIZATION: This SBIR has strong commercialization potential Phase III should provide an information technology solution to Department of Defense, Department of Veterans Affairs and commercial healthcare activities. This technology may potentially benefit NATO countries as they move to modernize their healthcare delivery systems.

Candidate technologies designed and demonstrated under this SBIR project should be readily applicable to provision of health care within civilian settings with extensive continuum of care business practices that resemble those of the military; these would include those enterprises such as HMOs that encompass a full range of services from outpatient primary care in remote clinics to intensive care within large teaching medical centers.

REFERENCES:

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(4) Usama Fayyad and Ramasamy Uthurusamy, *Data mining and knowledge discovery in databases*, Communications of the ACM, 39(11), November 1999.

KEYWORDS: Information Technology, Military, Healthcare, Data marts, Data warehouse

9.0 SUBMISSION FORMS AND CERTIFICATIONS

Section 9.0 contains:

Reference A: **Cost Proposal Outline**
A cost proposal following the format in Reference A must be included with each proposal submitted.

Reference B: **Fast Track Application Form**
A DoD program under which projects that attract outside investors receive interim funding and selection for Phase II award provided they are "technically sufficient" and have substantially met Phase I goals.

Reference C: **Proposal Receipt Notification Form**

Reference D: **Directory of Small Business Specialists**

Reference E: **SF 298 Report Documentation Page**

Reference F: **DoD Fast Track Guidance**

Reference G: **DoD's Critical Technologies**

Reference H: **DoD SBIR/STTR Mailing List Form**

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
COST PROPOSAL

Background:

Offerors should indicate the following terms, as appropriate, in their proposal, following the instructions in Section 3.4(m) of this solicitation. If desired, offerors may complete and submit their cost proposal electronically, through the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission).

Cost Breakdown Items (in this order, as appropriate):

1. Name of offeror
2. Home office address
3. Location where work will be performed
4. Title of proposed effort
5. Company's taxpayer identification number and CAGE code. *(Note: Offerors that do not yet have these items -- e.g., because the company does not yet exist at the time of proposal submission – should so indicate in the cost proposal. Such offerors, if selected for award, should talk with their DoD contracting officer about obtaining these items, both of which are required before a contract can be awarded.)*
6. Topic number and topic title from DoD Solicitation Brochure
7. Total dollar amount of the proposal
8. Direct material costs
   a. Purchased parts (dollars)
   b. Subcontracted items (dollars)
   c. Other
      (1) Raw material (dollars)
      (2) Your standard commercial items (dollars)
      (3) Interdivisional transfers (at other than cost dollars)
   d. Total direct material (dollars)
9. Material overhead (rate_____%) x total direct material = dollars
10. Direct labor (specify)
    a. Type of labor, estimated hours, rate per hour and dollar cost for each type (e.g., "computer programmer, 40 hours, $26 per hour, $1040 cost") Include the name as well as hours, etc. of all key personnel.
    b. Total estimated direct labor (dollars)
11. Labor overhead
    a. Identify overhead rate, the hour base and dollar cost
    b. Total estimated labor overhead (dollars)
12. Special testing (include field work at government installations)
    a. Provide dollar cost for each item of special testing
    b. Estimated total special testing (dollars)
13. Special equipment
    a. If direct charge, specify each item and cost of each
    b. Estimated total special equipment (dollars)
14. Travel (if direct charge)
    a. Transportation (detailed breakdown and dollars)
    b. Per diem or subsistence (details and dollars)
    c. Estimated total travel (dollars)
15. Subcontracts (e.g., consultants)
    a. Identify each, with purpose, and dollar rates
    b. Total estimated subcontracts costs (dollars)
16. Other direct costs (specify)
    a. Total estimated direct cost and overhead (dollars)
17. General and administrative expense
    a. Percentage rate applied
    b. Total estimated cost of G&A expense (dollars)
18. Royalties (specify)
    a. Estimated cost (dollars)
19. Fee or profit (dollars)
20. Total estimate cost and fee or profit (dollars)
21. The cost breakdown portion of a proposal must be signed by a responsible official, and the person signing must have typed name and title and date of signature must be indicated.
22. On the following items offeror must provide a yes or no answer to each question.
    a. Has any executive agency of the United States Government performed any review of your accounts or records in connection with any other government prime contract or subcontract within the past twelve months? If yes, provide the name and address of the reviewing office, name of the individual and telephone extension.
    b. Will you require the use of any government property in the performance of this proposal? If yes, identify.
    c. Do you require government contract financing to perform this proposed contract? If yes, then specify type as advanced payments or progress payments.
23. Type of contract proposed, either cost-plus-fixed-fee or firm-fixed price.

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the SBIR Fast Track, a company must submit a Fast Track application and meet the other requirements detailed in Section 4.5 of the solicitation. This form, when completed and signed by both the company and its investor, should be included as the cover sheet of the Fast Track application. Instructions on where to submit the application are on the back of this form.

TOPIC #: ______________ CONTRACT #: ______________________ PHASE I EFFECTIVE START DATE: ______________

SPONSORING DOD COMPONENT: ______________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ______________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________ STATE: __________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ______________________

BUSINESS CERTIFICATION:

	YES	NO
> Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants – see the BMDO section of this solicitation)	☐	☐
> Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference F)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

Caution: knowingly and willfully making any false, fictitious, or fraudulent statements or representations above may be felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

PROPOSED SBIR AND MATCHING FUNDS:

> Proposed DoD SBIR funds for the interim effort: $______________

> Proposed DoD SBIR funds for Phase II: $______________

> Total proposed DoD SBIR funds (interim + Phase II): $______________

> Amount of matching funds (cash) the investor will provide: $______________

By signing below, the parties are stating that the outside investor will provide matching funds, in the amount listed above, contingent on the company's selection for Phase II SBIR award. If the matching funds are not transferred from the investor to the company within 45 days after DoD has notified the company that it has been selected for Phase II award, the company will be ineligible to compete for a Phase II award not only under the Fast track but also under the regular Phase II competition, unless a specific written exception is granted by the Component SBIR program manager.

COMPANY OFFICIAL	OUTSIDE INVESTOR OFFICIAL
NAME: ______________________	NAME: ______________________
TITLE: ______________________	TITLE: ______________________
TELEPHONE: __________________	TELEPHONE: __________________
SIGNATURE ______________ DATE ______	SIGNATURE ______________ DATE ______

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING FAST TRACK COVER SHEET

SUBMISSION:

Submit the Fast Track application, including the three items discussed in Section 4.5(b), to the technical monitor for your Phase I project. In addition, submit a copy of the entire application to the Program Manager of the DoD Component funding the SBIR project (addresses below). Finally, send a copy of this application cover sheet, when completed, to the DoD SBIR Program Manager, OSD/SADBU, 1777 N. Kent Street, Suite 9100, Arlington, VA 22209. Do not submit other items in the Fast Track application to the DoD SBIR Program Manager.

Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
ONR 362 SBIR
ATTN: Vincent Schaper
800 N. Quincy Street
Arlington, VA 22217-5660

Department of the Air Force
AFPL/XPTT, Steve Guilfoos
1864 4th Street, Suite 1, Bldg.15
Wright Patterson AFB, OH 45433-7131

Defense Advanced Research Projects Agency
ATTN: SBIR Program Manager Ms. C. Jacobs
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Chemical and Biological Defense Program
Dr. Kenneth A. Bannister
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Ballistic Missile Defense Organization
ATTN: ST/SBIR (Jeff Bond)
7100 Defense Pentagon,
FOB #2
Washington, DC 20301-7100

Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington, DC 20301-3040

Defense Threat Reduction Agency
ATTN: AM/SADBU, Mr. Bill Burks
45045 Aviation Drive
Dulles, VA 20166-7517

US Special Operations Command
ATTN: SOSB/Ms Karen L. Pera
7701 Tampa Point Blvd.
MacDill AFB, FL 33621-5323

National Imagery and Mapping Agency
Derrick Riddle
SBIR Program Manager
4600 Sangamore Road
ATTR, MS-D82
Bethesda, MD 20816

ELECTRONIC VERSIONS OF THIS FORM ARE AVAILABLE.

This form is available in HTML format, which allows you to complete the form electronically and print out a hard copy to submit to DoD – see http://www.sbirsttr.com/sbirmisc/refb/form.html. Also, additional hard copies of this form may be obtained from:

DoD SBIR Support Services
7000 North Broadway
Building 1, Suite #108
Denver, CO 80221
(866) 216-4095

Proposer: If you wish to be notified that your proposal has been received, please submit this form *<u>with a stamped, self-addressed envelope</u>.*

Remember to Stamp Your Self-Addressed Envelope!

TO: ____

____

____

Fill in firm's name and mailing address

SUBJECT: SBIR Solicitation No. 01.2

Topic No.
Fill in Topic No.

Proposal Title ____
Fill in the Title of Your Proposal

This is to notify you that your proposal in response to the subject solicitation and topic number has been received by

____
Fill in name of organization to which you will send your proposal.

____ ______________
Signature by receiving organization Date

Associate Directors of Small Business assigned at Defense Contract Management Districts (DCMD):
(DCMD EAST -- http://www.dcmde.dla.mil; DCMD WEST -- http://www.dcmdw.dla.mil)

DCMD EAST (DCMDE-DU)
ATTN: Steven T. Shea
495 Summer Street, 8th Floor
Boston, MA 02210-2184
(617) 753-4318
(617) 7533174 (FAX)
bdu1150@dcmde.dla.mil

DCMC Atlanta (DCMDE-GADU)
ATTN: Jim Masone
805 Walker Street, Suite 1
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(770) 590-6551 (FAX)
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Standard form 298 (Rev. 2-89)
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REF E

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to stay within the lines to meet optical scanning requirements.

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C - Contract	**PR** - Project
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Standard Form 298 (Rev. 2-89)

DoD Fast Track Guidance

This paper contains DoD's official guidance on what types of relationships between a small company and outside investors in the company qualify as an investment under the SBIR and STTR Fast Track ("Fast Track investment"). It includes specific examples of company-investor relationships that we have been asked about and our official responses on whether these relationships qualify as a Fast Track investment. If you have questions about whether a particular company-investor relationship qualifies, please contact the DoD SBIR/STTR Help Desk (tel. 866/216-4095, fax 866/888-1079, e-mail SBIRHELPDESK@pbcinc.com). The Help Desk will refer any policy or substantive questions to appropriate DoD personnel for an official response.

I. General Guidance on What Qualifies As A "Fast Track Investment"

- The investor must be an "outside investor," which may include such entities as another company, a venture capital firm, an individual "angel" investor, a non-SBIR/non-STTR government program, or any combination of the above. It does not include the owners of the small business, their family members, and/or "affiliates" of the small business, as defined in Title 13 of the Code of Federal Regulations (C.F.R.), Section 121.103. As discussed in that Section:
    - Concerns are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.
    - [We] consider factors such as ownership, management, previous relationships with or ties to another concern, and contractual relationships, in determining whether affiliation exists.
    - Individuals or firms that have identical or substantially identical business or economic interests, such as family members, persons with common investments, or firms that are economically dependent through contractual or other relationships, may be treated as one party with such interests aggregated.

  Although DoD is guided by this definition of affiliation in the Code of Federal Regulations, we also exercise our own discretion in determining whether a particular entity qualifies as an "outside investor."

- The <u>investment</u> must be an arrangement in which the outside party provides cash to the small company in return for such items as: equity; a share of royalties; rights in the technology; a percentage of profit; an advance purchase order for products resulting from the technology; or any combination of the above. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.).

II. Specific examples of What Does and Does Not Qualify As a "Fast Track Investment"

<u>A. Examples of What Qualifies as an "Outside Investor"</u>

(1) Can a small company contribute its own internal funds to qualify for the Fast Track?

No. DoD is seeking outside validation of the commercial potential of the company's technology, and therefore requires that the funds come from an outside investor. Also, cash from an outside investor shows up plainly on the company's books and therefore can be more readily verified than a company's own matching contribution.

(2) Company A spins off company B, which wins a phase I SBIR award. Company A then wants to contribute matching funds to qualify company B for the Fast Track. Can A be considered an outside investor for purposes of the Fast Track?

In making our determination of whether company A is an outside investor, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103, discussed above. Our presumption is that in this example A and B would be considered "affiliates," and that A would therefore not be an outside investor for purposes of the Fast Track. However, that presumption could be rebutted by showing, for example, that the spin-off occurred several years ago and that A and B do not exercise control over one another, do not have common ownership or management, have different business interests, etc.

(3) Small company S wins a phase I SBIR award. The president of S is a major shareholder in another company Y, which wants to contribute matching funds to qualify S for the Fast Track. Can Y be considered an outside investor?

Our presumption is that Y would not be considered an outside investor. Our determination would be guided by whether the president's stake in Y is large enough that S and Y would be considered "affiliates" under 13 C.F.R. Sec.121.103. Subsection (c.) of Section 121.103 specifically discusses affiliation based on stock ownership:

c. Affiliation based on stock ownership.
   1. A person is an affiliate of a concern if the person owns or controls, or has the power to control 50 percent or more of its voting stock, or a block of stock which affords control because it is large compared to other outstanding blocks of stock.
   2. If two or more persons each owns, controls or has the power to control less than 50 percent of the voting stock of a concern, with minority holdings that are equal or approximately equal in size, but the aggregate of these minority holdings is large as compared with any other stock holding, each such person is presumed to be an affiliate of the concern. If S and Y are found to be affiliates, we would determine that Y is not an outside investor.

(4) Does the outside investor have to be a single entity (e.g., a single venture capital firm) or can it be more than the entity (e.g., two angel investors and a venture capital firm)?

It can be more than one entity.

(5) Small company A contributes matching funds to small company B in order to qualify B for the Fast Track, and, at the same time, B contributes matching funds to A in order to qualify A for the Fast Track. Do A and B qualify as outside investors under the Fast Track?

No. A and B's relationship is such that their investment in each other would not provide outside validation of the commercial potential of their respective SBIR projects. We would therefore not consider them to be outside investors for purposes of the Fast Track.

(6) Can the brother of an employee of small company S contribute funds to qualify S for the Fast Track?

Probably not. Again, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103. The brother presumptively would be an affiliate of company S and not an outside investor.

(7) Venture capital firm V currently is a 22 percent shareholder in small company S. Can V invest additional funds in S to qualify S for the Fast Track?

Our presumption is yes. In making our determination, we would be guided by whether V and S are "affiliates," as defined in 13 C.F.R. Sec. 121.103. Section 121.103 provides (in subsection (b)(5)) that a venture capital firm is not affiliated with a company if the venture capital firm does not control the company -- e.g., by owning more than 50 percent of the stock of a small company (prior to its investment under the Fast Track), as described in 13 C.F.R. 107.865.

(8) Large company L makes a cash investment in small company S, and then serves as a subcontractor to S on an SBIR project. Can L's investment in S count as a matching contribution for purposes of the Fast Track?

Only L's cash investment net of its subcontracting effort can count as matching funds for purposes of the Fast Track. For example, if L invests $750,000 in S and subcontracts with S for $250,000, only L's net contribution ($500,000) can count as matching funds for purposes of the Fast Track.

(9) Company Y makes a cash investment in small company S for purposes of the Fast Track, and also enters into a separate contract with S under which Y provides certain goods/services to S in return for $500,000. Can Y's cash investment in S count as a matching contribution for purposes of the Fast Track?

As in the previous example, only Y's cash investment net of the $500,000 it receives from S can count as matching funds for purposes of the Fast Track. However, if the separate contract between Y and S pre-dates S's submission of its phase I SBIR proposal, Y's entire cash investment can count as matching funds for purposes of the Fast Track.

(10) A group of investors wishes to invest funds in small company S to qualify S for the Fast Track. One of the investors is the mother of S's president, who wants to contribute $50,000 toward the effort. Can the group's investment in S count as a matching contribution to qualify S for the Fast Track?

The mother's investment of $50,000 does not count, because she is not an outside investor (see item (6) above). Contributions of the other investors can count provided that they meet the other conditions for the Fast Track (e.g., each must be an outside investor).

B. Examples of What Qualifies as an "Investment"

(1) Can a loan from an outside party qualify as an "investment" for purposes of the Fast Track?

No. The rationale behind the Fast Track is that an outside party is betting on the company's success in bringing the technology to market -- not just its ability to repay a loan.

(2) How about a loan that is convertible to equity?

A loan that is convertible to equity at the company's discretion would count as an investment under the following circumstances: (1) the loan is provided by a public entity (e.g., a state agency), or (2) the loan is provided by a private entity, and the SBIR company actually converts the loan to equity before the end of phase I.

(3) Can in-kind contributions from an outside investor count as matching funds under the Fast Track?

No. The matching contribution must be in cash. A cash contribution is a stronger signal of the outside investor's interest in the technology, and can be readily verified.

(4) Can a purchase order from an outside investor count as a matching contribution under the Fast Track?

An advance purchase order for new products resulting from the SBIR project can count as a matching contribution under the Fast Track. The purchase order must be for one or more products directly resulting from the SBIR project (including, for example, a duplicate of the prototype that will be delivered to DoD at the end of phase II). The investor must provide its cash payment to the small business during phase II, within the time frame set out in the solicitation (section 4.5). To ensure that the investor's funds are "at risk," the payment cannot be refundable to the investor if the product is not delivered or does not work.

(5) Can the funds raised from an initial public offering (IPO) count as matching funds for purposes of the Fast Track?

Yes, as long as the offering memo indicates that a portion of the funds from the IPO will pay for work (e.g., R&D, marketing, etc.) that is related to the SBIR project.

(6) If large company L pays small company S for work related to S's SBIR project and expects a deliverable (goods or services) from S in return, would that qualify as an "investment"?

With the exception of an advance purchase order (discussed in (4) above), this arrangement would not qualify as an investment, for the same reason a loan does not qualify. Specifically, in this situation the large company is not betting on the small company's success in bringing the technology to market, but merely on its ability to provide the deliverable.

C. Examples Re: Timing/Logistics of the Fast Track Investment

(1) Can entity E's investment in small company S during the first month of S's phase I SBIR project count as a matching contribution to qualify S for the Fast Track?

Yes, provided that E is an outside and that the other Fast Track conditions are met. The investment can occur any time after the start of the phase I project.

(2) Small company A, which has won a phase I award, spins off small company B to commercialize the SBIR technology. A then convinces angel investor I to invest funds in B. Can I's investment in B count as a matching contribution to qualify A for the Fast Track?

For I's investment in B to qualify A for the Fast Track, DoD must determine that A and B are substantially the same entity, as evidenced, for example, by their meeting the definition of "affiliates" in 13 C.F.R. Sec.121.103.
If DoD determines that A and B are substantially the same entity, I's investment in B could qualify A for the Fast Track. Of course, the parties must also meet the other conditions for the Fast Track (e.g., I must be an outside investor).

(3) Small company S is collaborating with a university on an STTR project. Investor I wishes to provide funds to the university in order to qualify S for the STTR Fast Track. Can I's investment in the university count as a matching contribution to qualify S for the Fast Track?

In order to qualify S for the STTR Fast Track, I's investment of funds must be in small company S, not in the university. S can then subcontract some of the funds to the university. The rationale is that a cash investment in the small company is a very strong indication of commercial potential, whereas an investment in the university is less so.

(4) Must the activities funded by the investor be included in the statement of work for the small company's phase II contract?

No. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.), but these activities need not be included in the phase II contract's statement of work. In practice, funds from private sector Fast Track investors generally are not included in the phase II contract's statement of work, whereas funds from government Fast Track investors (such as DoD acquisition programs) sometimes are.

DoD's Key Technology Areas

The following is an outline of the Defense Technology Area Plan.

1.	**Air Platforms** -- Fixed-Wing Vehicles; Rotary-Wing Vehicles; Integrated High Performance Turbine Engine Technology (IHPTET); Aircraft Power; High-Speed Propulsion and Fuels.
2.	**Chemical / Biological Defense** -- CB Detection; CB Protection; CB Decontamination; CB Modeling and Simulation; Medical Chemical Defense; Medical Biological Defense.
3.	**Information Systems Technology** – Decision making; Modeling & Simulation Technology; Information Management Assurance & Distribution; Seamless Communication; Computing and Software Technology.
4.	**Ground and Sea Vehicles** -- Ground Vehicles; Surface Ship Combatants; Submarines.
5.	**Materials / Processes** -- Materials and Processes for Survivability, Life Extension, and Affordability; Manufacturing Technology; Civil Engineering; Environmental Quality.
6.	**Biomedical** -- Infectious Diseases of Military Importance; Combat Casualty Care; Military Operational Medicine; Medical Radiological Defense.
7.	**Sensors, Electronics and Battlespace Environment** -- Radar Sensors; Electro-Optical Sensors; Acoustic Sensors; Automatic Target Recognition; Integrated Platform Electronics; Radio-Frequency Components; Electro-Optical Technology; Microelectronics; Electronic Materials; Electronics Integration Technology; Terrestrial Environments; Ocean Battlespace Environments; Lower Atmosphere Environments; Space/Upper Atmosphere Environments.
8.	**Space Platforms** -- Launch Vehicles; Space Vehicles; Propulsion [Integrated High-Payoff Rocket Propulsion Technology (IHPRPT)].
9.	**Human Systems** - - Information Display and Performance Enhancement; Design Integration and Supportability; Warrior Protection and Sustainment; Personnel Performance and Training.
10.	**Weapons** - - The Weapons area has three broad categories. 1) Conventional Weapons: Countermine/Mines; Guidance and Control; Guns; Missiles; Ordnance; Undersea Weapons; and Weapon Lethality / Vulnerability. 2) Directed-Energy Weapons: Lasers; and High-Power Microwave. 3) Electronic Warfare: Threat Warning; Self-Protection; and Mission Support.
11.	**Nuclear Technology - -** Warfighter Support; Systems Effects and Survivability; Test and Simulation Technology; Scientific and Operational Computing.

Note: The above information is a summary of the information contained in documents "Defense Technology Plan" (DTIC # A285415) and "Defense Science and Technology Strategy" (DTIC # A285414).

The DoD SBIR Mailing List

The DoD SBIR Program Office maintains a computerized listing of firms that have requested to be sent copies of the DoD SBIR Solicitations on a regular basis. If you would like to remain, or be added to this listing, please mail in this form.

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Denver, CO 80221

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Addendum to FY2001.2 Navy Topics

Proposals submitted against topics in this Navy FY2001.2 Addendum will follow the "Navy Proposal Submission" instructions presented in the Navy section of this DoD Solicitation.

Topic Numbers	Point of Contact	Activity	Phone
N01-184 to N01-185	Mr. Bill Degentesh	NAVSEA	202-781-3740
N01-186	Mr. Douglas Harry	ONR	703-696-4286
N01-187 to N01-192	Ms. Carol Van Wyk	NAVAIR	301-342-0215

Do not contact the Program Managers for technical questions. For technical questions, please contact the topic authors during the pre-solicitation period from 1 May 2001 until 1 July 2001. These topic authors are listed on the Navy website under "Solicitation" or the DoD website. After 1 July, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website for more information.

NAVY 01.2 ADDENDUM SBIR TITLE INDEX

Naval Sea Systems Command (NAVSEA)

N01-184 Simulation of Radiation Scattering and Coupling Properties of Large Phased Arrays
N01-185 Intelligent Flight Deck Camera Control with Video Mosaic

Office of Naval Research (ONR)

N01-186 Environmental Data Fusion for Mine Warfare

Naval Air Systems Command (NAVAIR)

N01-187 Optimal Diversity Reception for Ship Relative Global Positioning System (SRGPS)
N01-188 Smart Flat Panel Multifunction Color Display (MFCD) with Positive Pilot Feedback
N01-189 Open Architecture Software Using Middleware Isolation Layers
N01-190 Multi-Level Security in Real-Time Shared Memory Avionic Systems
N01-191 Autonomous Vehicle Management System
N01-192 Personal Computer (PC) Graphics Support for Texel Level Sensor Simulation

Naval Sea Systems Command (NAVSEA)

N01-184 TITLE: Simulation of Radiation Scattering and Coupling Properties of Large Phased Arrays

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: DD-21

OBJECTIVE: Develop computer simulation program for modeling large phased arrays containing thousands of elements that are typically found in shipboard antenna applications. The models should be able to simulate the truncation effects of these large arrays and accurately predict the modifications introduced in their radiation, scattering, and EMI coupling characteristics of these arrays.

DESCRIPTION: Large phased arrays are found in many radar and communication systems. They are typically analyzed by using perturbation schemes, which assume that the field distribution in the aperture of the array is the same as that in a windowed doubly periodic infinite array. This approximation is introduced because the number of unknowns associated with the typical shipboard phased array problem becomes unmanageably large and the problem cannot be handled by using existing EM solvers.

However, the use of such a "windowing" approximation can introduce significant errors in the characterization of the array – in terms of its radiation, scattering and EMI coupling characteristics. For instance, the estimate of the level of the far-field sidelobes of an array can have significant errors under the above approximation. Likewise the RCS of a large phased array cannot be accurately predicted by using a perturbational approach applied to the infinite array problem. Furthermore, in estimating the EMI levels, the scattering from the array must be accurately modeled together with the coupling to the internal electronics. The estimates of the scattering and internal coupling levels may also be unreliable when a crude approximation based on a simple truncation of an infinite array is used.

The objective of this effort would be to develop accurate, efficient, yet reliable methods for simulating large but finite phased arrays. As mentioned above the existing methods are limited in their ability to handle realistically large phased arrays and, hence, new innovative techniques are needed to model the problem.

The technique proposed should be applicable to phased arrays of interest to the DON-DD21 program, containing thousands of elements. Also, the technique should be general enough to handle different types of phased array elements that may be used in shipboard antenna arrays. Finally, the method should be applicable to arbitrary geometries of the template that may be used to truncate the array.

PHASE I: Develop accurate numerical technique for analyzing large phased arrays with q view to predicting their radiation, scattering and coupling characteristics. Validate the technique by comparing the results with those derived by using currently available EM modeling tools for moderate sized arrays. Demonstrate how these results can be extrapolated for much larger size arrays that cannot be handled via present simulation techniques.

PHASE II: Develop software module based on the technique developed in Phase I, complete with graphical user interface, to handle large phased arrays with elements typically found in shipboard antenna applications. Validate the results for pattern modification, change in TCS and internal coupling effects of the truncation by comparing with the measured data.

PHASE III: Successful design capability should transition to the Navy's Integrated Topside Design Program.

COMMERCIAL POTENTIAL: The commercial world will benefit directly from this software module in solving large array problems, e.g., companies in the communication business.

KEYWORDS: radiation; scattering; EMI coupling; phased arrays

N01-185 TITLE: Intelligent Flight Deck Camera Control with Video Mosaic

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID

OBJECTIVE: Develop a system that provides full and constant video surveillance of the flight deck of an aircraft carrier using minimal man-in-the-loop operation. This would require the following technology advances: (1) Intelligent and automatic control

of a pan/tilt/zoom camera for detailed coverage of both routine/repeated tasks and non-routine/emergency incidents, and (2) Machine vision algorithms that piece together video feeds from multiple cameras with different viewing angles and fields into one seamless mosaic.

DESCRIPTION: In order to constantly monitor flight operations, aircraft carriers employ a system of cameras and displays called the Integrated Launch and Recovery Television System. The ILARTS system allows the ready rooms, flight deck control, and the combat information center to view recoveries, launches, aircraft movements on the deck, and other activities, enabling a rapid response in case of emergencies as well as a tape archive that can be used to investigate a mishap. A key component of ILARTS is the manned island camera, which is located about 40 feet above the flight deck. The island camera is a pan, tilt, and zoom (10:1 zoom lens) that picks up the aircraft as it grabs one of the arresting wires, zooms in for a close up to pick up the aircraft's side number and follows the arresting wire back to its sheaves to determine which of the wires was engaged. If the aircraft bolters, the cameraman follows the aircraft as it departs the ship. The island camera also tracks each of the aircraft as it launches from the time it is in the catapult out to a half mile.

The island camera resides in an enclosure on the inboard forward corner at the 07 level which has been built as an air conditioned weather tight compartment surrounded by a polycarbonate window. This island appendage is location-critical because of the required angles of visibility from this camera. There would be significant benefit to the ship in eliminating this island camera space: a cost avoidance for construction in excess of $200K, reduced island radar cross section, potential workload reduction of 1-3 MY/Y through reduction of camera operators (annual savings of $75K to $225K per ship), weight reduction of more than 8 long tons, VCG reduction of 0.03 feet, and starboard list reduction of 0.03 degrees. To accomplish this, the Navy needs autonomous, intelligent control of the pan/tilt/zoom camera for routine tasks, plus a way of remotely controlling the camera from the ILARTS control room one level underneath the flight deck for non-routine tasks.

Routine tasks requiring automatic camera control would be: (1) Recovery: Track the recovering aircraft once it crosses the ramp, zoom in on the side number, zoom out, track to it's initial spot; and (2) Launch: Cover each aircraft launch out to a half-mile. Data to support automatic control are the following. For recovery, the SPN-46 Precision Approach Radar and the Virtual Imaging System for Approach and Landing (VISUAL) electro-optic tracker provides distance to ramp and closing speed information. VISUAL is currently in development. For launch, the catapult control system indicates when a catapult launch has commenced. Data for both recovery and launch will also be available through the Aviation Data Management and Control System (ADMACS), an Air Department-wide LAN on the carrier. ADMACS is currently in development.

Non-routine tasks requiring manual intervention include emergencies or activities such as a flight deck explosion, blown tire, man overboard rescue operation, or cargo transfer via helicopter ("vertical replenishment" or VERTREP). This remote control requires (1) obtaining the situational awareness needed to recognize that an activity is taking place that requires detailed video coverage by the pan/tilt/zoom camera, (2) initial acquiring of the aircraft/helicopter/person/object by the camera and then (3) pan/tilt/zoom control of the camera to achieve a detailed view of the aircraft/object and the control needed to continue the view of the object if the aircraft/object is moving. These must occur during very high-tempo operations where multiple activities are occurring simultaneously on the flight deck and in the air space around the ship and includes both day and night operations.

Because there is no spot high enough to mount one camera for a "God's eye view" of the flight deck, multiple fixed cameras will be used to provide the video feeds necessary to give the ILARTS operator some level of situational awareness needed for remote operation of the pan/tilt/zoom camera. However, utilizing one display, rather than multiple displays, is necessary to minimize equipment costs, minimize operator scan and fatigue, and feasibly fit into a constrained space. Therefore, the Navy needs one seamless view of the flight deck and surrounding area. Algorithms would need to be developed that transform each camera's viewing angle into one common viewing angle and match the "seams" between fields of view. (Note: the "seams" may include both horizontal (pan) seams and vertical (tilt) seams.)

Areas for camera coverage: (1) Flight deck, (2) Half mile forward of the bow and waist catapults, (3) Quarter mile around the flight deck for VERTREP or search and rescue (SAR) operations. Analysis of number of cameras and lens capabilities to completely cover the scene is germane to this topic. However, selection of the type of camera to operate in all light and weather conditions is not necessary for this topic. Proposals to this topic should be focused on the algorithms necessary the intelligent camera control and mosaic of multiple video feeds. Means of tracking aircraft other than visual (such as laser or active emissions from aircraft) could be considered for augmenting the camera suite if necessary.

PHASE I: Develop a concept and demonstrate the feasibility of that concept towards achieving the stated objective. This should involve developing algorithms and testing those algorithms in a lab environment. For the intelligent camera control, a lab demonstration could show a pan/tilt/zoom camera tracking moving objects on video or following a prescribed script that simulates flight operations. The concept should also identify interfaces to carrier systems, input data for triggering control sequences, output data from pan/tilt/zoom unit providing camera position for feedback, and any additional hardware required. For the video mosaic, the lab demonstration should manipulate multiple video streams from different viewing angles and display the video onto one monitor with one viewing angle. The concept should also identify the number of fixed cameras and mounting locations to achieve complete coverage as described above. In addition, identify interfaces and hardware required for remote

operation of the pan/tilt/zoom camera. The Phase I final report should include an analysis of alternative concepts as well as an assessment of cost.

PHASE II: Develop a prototype system and demonstrate it aboard a carrier during flight operations at sea. The demonstration should show the system automatically controlling a pan/tilt/zoom camera for the routine tasks stated above, continuously keeping the aircraft in the field of view during recovery or launch operations. It should display complete flight deck coverage (as described above) on one monitor in the ILARTS Control Room. It should demonstrate remote manned camera control from the ILARTS Control Room and from Primary Flight Control (PriFly). An operator controlling the camera remotely should be able to find and zoom-in on an object on the flight deck in any arbitrary location in 4 seconds or less. The Phase II final report should include an execution plan for Phase III, including cost and schedule.

PHASE III: Produce and field systems for the 12 aircraft carrier fleet, plus systems for lab and training. Assist in providing the logistics necessary to operate and maintain the systems.

COMMERCIAL POTENTIAL: This technology would satisfy any application which requires monitoring multiple cameras with multiple viewing angles. There would be numerous opportunities in the commercial sector, including entertainment, sports, traffic management and security/surveillance.

KEYWORDS: Machine vision, Video mosaic, Intelligent control, Human factors

Office of Naval Research (ONR)

N01-186 TITLE: Environmental Data Fusion for Mine Warfare

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Further the development of technology to apply environmental data to mine warfare. This includes the human/computer interface, knowledge discovery in databases (KDD), retrieval of knowledge and data from very large databases, and the interfacing and exchange of data between large databases.

DESCRIPTION: The focus of this SBIR topic is to stimulate bold new concepts for significantly improved application of environmental data to mine warfare. Current Naval doctrine calls for operations in the littoral regions of the oceans. Effective counter measures against enemy mines in the littoral require knowledge of all aspects of the complicated undersea environment. Typical databases include: historical and recently acquired bathymetry and bottom composition, the spatial/temporal distribution of physical, chemical, and biological properties in the water column, and the locations of detected, classified and identified objects on the bottom and in the water column. Metadata, descriptions of the basic data, will be generated. These databases will be heterogeneous, comprised of maps, images, sets, lists and descriptions. The size and complexity of these databases may prohibit storage as relational databases and favor Object Oriented DataBases (OODB). On the other hand, maps are usually stored as Geographical Information Systems (GIS). Methods of overcoming known difficulties with both OODB and GIS are of interest. These databases must be interfaced for analysis. Methods of simultaneously working with OODB and GIS (i.e. the integration of spatial and non-spatial data) are of interest. Analysis will require exchange of databases from one set of software to another. Analysis will create linked or integrated data systems from these multiple databases. Information and data must be retrieved from these databases on demand and as required by the analysis. Methods of data retrieval are of interest. The knowledge required for effective action must be extracted from these diverse data sets. The technologies of Knowledge Discovery in Databases (KDD), Data Mining, learning algorithms, and feature extraction are of interest. Registration of images acquired by different sensors or at different times is of interest. Detection of change in images acquired at different times is of interest. The extracted knowledge along with the supporting data must be presented to the human operator in a meaningful way. Innovative hardware and software for human/computer interfaces are of interest. This includes technology for perceiving and interacting with the knowledge and data through multiple senses (i.e. visual, aural, tactile), three dimensional and temporal displays, and combining GIS display with an object oriented retrieval capability.

PHASE I: Develop a complete algorithm or detailed description of the proposed data fusion concept. If the concept involves hardware produce a design. This algorithm, description, or design and supporting documentation should be sufficient to convince qualified engineers that the proposed concept is technically feasible.

PHASE II: Produce and demonstrate performance of a computer program based on the algorithm or description of the concept. If the concept involves hardware, produce and demonstrate performance of an exploratory Development Model (XDM). Demonstrate performance in such a way as to convince qualified engineers that the proposed concept is capable of meeting requirements in an operational environment.

PHASE III: Team with the manufacturer of one of the Navy's underwater MCM reconnaissance systems or environmental tactical decision aids, such as MEDAL, to integrate the concept into future generations. Team with manufacturers of commercial environmental fusion systems, such as satellite remote sensing displays, to integrate the concept into these products.

COMMERCIAL POTENTIAL: There is a growing commercial market in environmental data fusion using satellite remote sensing and historical geographical data. Weather display is a well-known application but also resource display has a significant application. There is a developing market fusing and displaying integrated social and natural science data. The technology developed in this SBIR may also be of use in the fields of medicine and gaming.

REFERENCES:

1. Samet, Hanan, 'Applications of Spatial Data Structures, Computer Graphics, Image Processing, and GIS", Addison-Wesley, 1990;
2. Fayyad, Piatetsky-Shapiro, Smyth, and Uthurusamy, eds. "Advances in knowledge discovery and data mining", AAAI Press, 1996

KEYWORDS: Object Oriented Databases (OODB), data mining, Knowledge Discovery in Databases (KDD), Geographic Information Systems (GIS), Database Exchange and Integration

Naval Air Systems Command (NAVAIR)

N01-187 TITLE: Optimal Diversity Reception for Ship Relative Global Positioning System (SRGPS)

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0

OBJECTIVE: Develop a SRGPS system with improved blockage, multi-path, and interference performance

DESCRIPTION: A cornerstone of the Navy SRGPS is the continuous transmission of shipside phase and pseudo-range measurements to the approaching aircraft. Continuity and quality of these satellite measurements critically drive the overall SRGPS navigation continuity and integrity. Faulty measurements, even if detected prior to transmission, impact system performance. Therefore, improvements are needed in shipside signal processing that are resistant to signal blockages, specular multi-path and interference, and to errors induced by radio frequency (RF) path elements such as nullers. As in civilian differential GPS (DGPS) landing systems, multiple antennas and receivers can provide redundancy for detecting multi-path, blockages, and phase anomaly events. However, in the shipboard environment, detection events will be more frequent. Correction of anomalies may be possible with techniques that optimally process the signals from multiple antennas. GPS-related technical papers have discussed processing techniques for civil, shore-based applications, which might be adaptable for shipboard applications. Also, it might be possible to combine such a technique with inertial aiding (for motion compensation) and with the newly defined military code (M-code) modulation for further improvements in multi-path rejection and tracking.

PHASE I: Analyze the architecture and performance of a multi-antenna optimal diversity reception system, including ship antenna configuration options, and interface with a ship inertial navigation system (SINS) or other aiding systems. The proof-of-concept will cover the impact of multi-path, blockage, attenuation, and nuller disturbances, for the current military precise (P/Y) code and the future M-code environments. Baseline comparisons will include conventional diversity systems.

PHASE II: Build and test a prototype P/Y code system to verify critical performance characteristics. The multi-antenna prototype system will be evaluated in RF-level simulations, and in field measurements.

PHASE III: Construct and install units aboard high-priority Navy vessels.

COMMERCIAL POTENTIAL: This technology applies directly to all safety-of-life DGPS systems, including Federal Aviation Administration (FAA) precision landing. Additionally, the developed multi-antenna signal processor will find application in code division multiple access (CDMA) wireless and phone station infrastructure for improved signal tracking and system capacity.

REFERENCES:

1. Final Draft, Operational Requirements Document I (ORD), Joint Precision Approach and Landing System (JPALS), ACAT Level ID, USAF 002-94-I, 4 Mar 98 (unclassified)
2. Joint Precision Approach and Landing System (JPALS), Single Acquisition Management Plan (SAMP), Version V12, 15 Sep 98 (unclassified)

3. Performance of Ship Relative GPS (SRGPS) Reference Station Diversity Reception Alternatives, Sennott, J.W., Senffner, D., and Najmulski, K. Proceedings of ION-GPS-2000, September 2000.
4. Design and Performance of Code Tracking for the GPS M-Code Signal, Betz, J.W., Proceedings of ION-GPS-2000, September 2000

KEYWORDS: Global Positioning System (GPS); Avionics; Receiver; Processing; Multi-path; Blockage

N01-188 TITLE: Smart Flat Panel Multifunction Color Display (MFCD) with Positive Pilot Feedback

TECHNOLOGY AREAS: Information Systems, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT: IC (PEO-A)

OBJECTIVE: Develop a multifunction flat panel display employing active matrix liquid crystal display (AMLCD) and MFCD technology. The flat panel display will use touch screen technology to activate sub-screens or internal systems. Each screen will provide both visual and biomechanical feedback. The biomechanical feedback may be done through attaching a device to the pilot or operator's glove using infrared technology. The MFCD may be utilized as both sensor and digital map displays.

DESCRIPTION: Cathode ray tube (CRT) MFCDs are an obsolescent reality. CRT orders and economical production rates are declining. Support of CRT MFCD beyond FY 02/03 will be increasingly risky due to parts availability. Long-term CRT availability is also questionable, and future cost is expected to increase. Over the last two years, suppliers have announced "last time buys" for many CRT components.

Conversion to smart AMLCD MFCDs will improve system performance and reliability, and reduce future procurement and life-cycle cost. The application of this technology to aviation display systems has the potential of $100,000,000 cost saving over the next 10 years. The reduction of mechanical components will result in greater reliability and reduced failures. The video display can be used as a smart system, which can be designed for pilot head-down use capable of displaying mission data, navigation, and other multifunction color display information in high performance aircraft.

PHASE I: Propose a design concept and identify technology developments required. Review current available AMLCD MFCD touch screen technologies against Navy requirements for aviation display systems. Identify technology deficiencies. Assess human factors associated with pilot workload and biomechanical feedback systems, which impart tactile sensory perception when the screen is touched. Determine performance parameters, feasibility and practicality of an AMLCD MFCD touch screen that provides both visual feedback and a biomechanical feedback that can be felt by the hand when the screen is touched

PHASE II: Develop the touch screen technology and biomechanical feedback system identified in Phase I. Integrate the touch screen flat panel display and biomechanical feedback system into a prototype display system. Demonstrate the performance characteristics and interface compatibility of the of the prototype display system with existing Navy data/software architecture. Finalize the design of the flat panel display, controller circuitry, system software, and biomechanical feedback device to fit within the current CRT cockpit envelope.

PHASE III: Conduct full-scale demonstration. Finalize production processes.

COMMERCIAL POTENTIAL: Commercial applications include the commercial aircraft industry, private aircraft and boats, PC gaming, automotive displays, and personal computers.

REFERENCES:
1. A Comparison of Numerical Data Entry with Touch Sensitive and Conventional Numerical Keypads, Report Number AFAMRL-TR-85-007.
2. "The Touch Panel System; Design and Development," Report Number RADC-TR-84-258. 3. "Six Sensor System," Roy O'Connor and David J. Bak, Design News, March 22, 1999.
3. "Advanced Displays and Interactive Displays Report Compendium II," Report AD Number: ADA380138.
4. Avionics Handbook, International Coverage of New and Emerging Technology; CRC Press, 2000 N.W. Corporate Blvd., Boca Raton, FL 33431-9868

KEYWORDS: Smart Flat Panel Multifunction Color Display; Positive Pilot Feedback; Active Matrix Liquid Crystal Display (AMLCD); Multifunction Color Display (MFCD); Touch Screen Technology; Visual and Mechanical Feedback.

N01-189 TITLE: Open Architecture Software Using Middleware Isolation Layers

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I:PEO-A; PEO-T

OBJECTIVE: Develop open architecture "middleware" software that allows reuse of application software modules from one real-time system to the next and facilitates "plug and play" of software from different sources into a real-time (particularly avionic) system.

DESCRIPTION: While plug and play application software has been very successful in the commercial personal computer (PC) arena (consider all the applications that can be "plugged" into Windows), few military real-time applications have achieved plug and play portability to, or reuse by other military real-time systems. Most real-time systems are built new from the ground up for each new program, even though many of the algorithms implemented are very similar to those in existing systems. This "reinvention of the wheel" for each new military system is costly and time-consuming resulting in very expensive systems, very long development times, and very expensive upgrades. Total ownership costs (TOC) have suffered. For example, programs such as the F-22 aircraft will have expended multi-billions of dollars on software over their life cycle. Without this new plug and play technology for software, the Joint Strike Fighter (JSF) will experience similar software cost growth. 40 percent savings on software TOC is reasonable if a technology for software reuse can be developed.

Modern military avionic real-time systems (e.g., JSF) are inherently different from most PC based commercial systems in that they must be deterministic; have low weight, volume, and power (and hence efficiency); and they must support multi-level security. Commercial middleware, such as common object request broker architecture (CORBA), has not been generally applicable to modern avionics because it has not been deterministic, it has not been efficient (the central processing unit (CPU) overhead for the middleware has sometimes exceeded 50 percent), and it has not provided multi-level security. Some efforts have been made toward developing real-time middleware. The Object Management Group has a limited development effort devoted to real-time middleware. The adaptive communication environment (ACE) object request broker (ORB) (TAO) was flown in the AV-8B at China Lake, CA. Results to date have shown that additional R&D are needed in the areas listed above. This effort seeks to perform the additional R&D needed—based on additional CORBA R&D or on entirely new concepts. The middleware should provide an interface "shell," defining the interfaces among application modules, and to the operating system, such that modules are easily reused in other systems having the same requirements. It should be able to handle worst case differences among modules (developed in different languages, presents a disparate interface, only available across a large area network (LAN), requires dynamic binding at run time, etc.), but scalable to add only minimal overhead when differences among modules are slight. CPU cycles should not be wasted resolving differences that do not exist. In fact it is anticipated that worst case difference will be seldom encountered. Consideration should be given to real-time systems with multi-processors, systems using both message passing and shared memory, systems with multiple virtual memory spaces, and systems with multi-level security. Consideration should also be given to the need to upgrade hardware periodically to new technologies that may include changing the CPU instruction set architectures or operating systems.

PHASE I: Define avionic real-time system performance requirements. Analyze, and document potential approaches to meet these requirements. Select an approach and document the effort for Phase II. Clearly show the rationale for the chosen approach over other approaches. Analyze the approach for determinism, computer resource utilization, and multi-level security. Address the feasibility and practicality of the proposed solution for a modern military avionic system.

PHASE II: Implement the approach chosen in Phase I. Design the system and develop the software. Demonstrate a prototype on a multi-processor system with multiple virtual memory spaces per processor using both shared memory and message passing. Evaluate the system in the areas of enhanced software modularity, portability, and reuse as well as for determinism, efficiency, and support for multi-level security.

PHASE III: Finalize the software. Perform a full-scale demonstration of the product.

COMMERCIAL POTENTIAL: This technology should be applicable to commercial real-time systems such as those used in telephony, medical imaging, and power plant and chemical plant control.

REFERENCES:

1. http://www.omg.org/
2. http://www.omg.org/techprocess/meetings/schedule/RT_Notification_RFP.html
3. http://www.omg.org/homepages/realtime/
4. http://cgi.omg.org/archives/realtime/msg00080.html
5. http://www.jast.mil/html/misnsys.htm; Avionics Architecture Definition Main Document

KEYWORDS: Real-Time Computing; Avionics; Software Portability; Open Architecture; Common Object Request Broker Architecture (CORBA); Middleware; Military Computing

N01-190 TITLE: Multi-Level Security in Real-Time Shared Memory Avionic Systems

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I:PEO-A; PEO-T

OBJECTIVE: Develop the hardware and software for the management and control of multi-level security in real-time, shared memory, multi-processor avionic systems.

DESCRIPTION: Next generation real-time avionic processors will be characterized by supporting multi-millions of lines of software classified at multiple security levels (unclassified, secret, top secret, etc), having multiple processors, and having a requirement for very high throughput. To avoid a "system high" environment where all multi-million lines of software must be treated as if they are classified at the highest level present (often top secret), dramatically increasing software costs, multi-level secure systems are desirable. In multi-level secure systems only the small amount of software that is actually classified needs to be specially managed. Current multi-level secure multi-processor avionic computers have used "message passing" communications among processors.

A faster and much lower latency (See Note 1) method of multi-processor communications is via "shared memory." The use of shared memory communications can result in reduced cost because, being faster, fewer processors are needed to do a given task. Several, shared memory interconnect systems (such as IEEE 1596 Scalable Coherent Interface) have demonstrated the improved speed benefits of shared memory. However, they do not meet the military's requirement for multi-level secure (unclassified though top secret) shared memory systems. The development of interconnect hardware, supporting interconnect software, and operating system are required.

Note 1: Used here, latency refers to the time required for the target application software to receive the needed data over the interconnect system. Message passing systems, even those with very high bit per second measurements, often invoke large delays before and after passing the data. Shared memory systems do not generally experience those delays.

PHASE I: Compare current shared memory interconnect system capabilities to the military requirement for multi-level secure multi-processor systems. Identify technology developments in interconnect hardware, supporting interconnect software, and operating system. Assess the feasibility and practicality of developing these technologies. Analyze the likelihood of security compromises with a shared memory interconnect system.

PHASE II: Develop the interconnect hardware, interconnect software, and operating system technologies identified in Phase I. Fabricate a prototype and demonstrate a secure shared memory interconnect system. Finalize system design.

PHASE III: Conduct full-scale field demonstration. Finalize production processes and software.

COMMERCIAL POTENTIAL: This project will develop high performance secure computer technology that will be applicable to all forms of military computing. However, the same technology should additionally be applicable to other industries needing security such as banking and Internet financial transactions.

REFERENCES:

1. http://www.computer.org/cspress/CATALOG/ST01049.htm
2. http://www.scizzl.com/
3. http://www.rapidio.org/

KEY WORDS: Secure Computing; Shared Memory; Real-Time; Multi-Processors; Avionics, Military Computing

N01-191 TITLE: Autonomous Vehicle Management System

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a system that allows for autonomous in-flight replanning of the air vehicle based on system status, sensor input, and preset mission objectives. The autonomous operation state models should provide the ground control station operator with improved vehicle health assessment, state prediction trend, vehicle operation options, and multi vehicle management. Technologies developed will support Vertical Takeoff Unmanned Air Vehicle (VTUAV) tactics for intelligence, surveillance,

and reconnaissance (ISR).

DESCRIPTION: The development of decision aiding processes for the VTUAV is critical to mission effectiveness of the system. Electro-optical/infrared (EO/IR), radio frequency (RF) information, navigation system, and vehicle health information will challenge the ability of the operator at the ground control station to correlate multiple sets of data from one or multiple VTUAVs while making time critical decisions.

The VTUAV system incorporates significant unmanned air vehicle (UAV) technical advances in virtually all of its major subsystems. To fully exploit the potential of this advanced ISR mission system, there is a need for effective decision aids to support tactical employment. Technologies that support real-time operation are of interest.

Autonomous operation models will enable the weapon system to achieve enhanced survivability. The autonomous operation models are needed to monitor vehicle health, subsystem state changes, and recommended courses of action to maximize ISR mission execution and indicate vehicle survivability.

Cognitive readiness of the ground control station operator with ISR information and tactical decision support solutions provided will incorporate the effects of significant battlefield conditions. The approach should also provide for learning experience; during the course of a mission the system should be capable of self-update based on the current conditions and mission results. Current conditions will be based on communication timing, route planning, weather, responses to threat, and recommended targets.

The implementation should be capable of rapid execution to support the real-time interaction of the ground control station operator. Autonomous operation decision aids in the ground control station and/or VTUAV will allow multiply vehicle operation by a single ground control station operator.

PHASE I: Provide a feasibility study to identify innovative approaches regarding the autonomy needed for surveillance, reconnaissance, and targeting missions for one to multiple UAVs. It should examine mission regeneration capabilities and applicable system technologies that would allow for real-time system reconfiguration and adaptive mission replanning based on self-system status, external sensor input, and external commands. The study should examine existing algorithms and algorithm development techniques enabling the vehicle to choose its mission and to adjust for unanticipated threats and changing conditions. This SBIR should identify the level of technology necessary for this autonomous operation (e.g., processor requirements, sensor type/quantity/resolution requirement) and compare the requirement to that available from commercial-off-the-shelf (COTS) components.

PHASE II: For the technology identified in Phase I, concept development will involve the generation of algorithms and testing on a software testbed. Hardware-in-the-loop (HWIL) will allow for demonstration and testing of autonomous capabilities identified in Phase I.

PHASE III: Demonstrate the ability to successfully integrate the tested algorithms from Phase II into the VTUAV or tactical control system (TCS).

COMMERCIAL POTENTIAL: In the growing market for UAVs and unmanned combat air vehicles (UCAVs), immediate customers for these products/technologies include both military and commercial markets. Autonomous health monitoring has application in commercial industry and on military aircraft and weapon systems. Fishing fleets, drug enforcement, and fire fighting are some commercial applications.

KEYWORDS: Autonomous Operation; Unmanned Air Vehicles (UAVs); Unmanned Combat Air Vehicles (UCAVs); Intelligent Control; Automated Vehicle Management Systems; Multi-Vehicle Management

N01-192 TITLE: Personal Computer (PC) Graphics Support for Texel Level Sensor Simulation

TECHNOLOGY AREAS: Information Systems, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: NAVAIR 1.0

OBJECTIVE: Develop a PC video card that incorporates dynamic texture indexing and three independent spline fogging.

DESCRIPTION: As the military relies more on advance sensors to deploy its weapons and execute missions, the importance of simulating these sensors for training at all levels has increased. Currently, only the most expensive simulation specific image generators can perform the high fidelity simulation of these sensors at the 60-Hz refresh rate and these systems cost from $300,000 to $1 million per graphic channel. The goal is to incorporate several of the most important high-end graphic capabilities into a desktop PC video card that would cost less than $25,000 per graphic channel. The capabilities to be

incorporated on the video card are three independent spline fog architecture and a high-bandwidth index texture color look-up capacity.

The problem with current fog simulations is that, no matter how the effects of visibility on surfaces/lights in the scene (propagation) are calculated, it is equally applied to all surfaces/lights as a function of range no matter the color, material, or spectral emission. Thus, a red, green, or blue surface at equal distance would fog (disappear) at the same range. In reality, because of different wavelengths of the light being reflected, the loss of energy to the environment (absorption and scattering) would be different for each surface. This difference would cause a different detection range for each surface (an example is the use of camouflage). The required PC video card conversion is hardware supporting multiple (3 or more) separate fog splines that can be rendered into a single scene at a 60 Hz refresh rate for proper in-band sensor propagation simulation.

An additional problem with low-cost simulation hardware is the lack of bandwidth to texture memory for real-time change of the texture color lookup tables separate from the paging of the texture data into texture memory. This limitation limits the use of the current generation high-fidelity sensor simulation technologies that calculate the in-band intensity of each texture pixel (texel) in real-time. It also wastes limited bandwidth resources to allow for updating of the scenes. More specifically, the current generation of sensor simulation software stores material indexes in textures instead of colors (called wavelength independent material texture maps) to allow for infrared, night vision, and out-the-window simulations to be calculated from a single stored database. The material indexes in the index map are then calculated with the effects of the diurnal cycle, weather, and other effects (possibly local illumination from lamp posts) taken into account. The results are stored in the texture color lookup tables that are applied to the textures in real time by indexing. Over time for a static eye-point, the environment changes and the texture color tables are updated to reflect these changes. The results are then applied to the current textures in real time to allow for the effects of thermal crossover.

PHASE I: Identify approaches for the implementation of real-time three spline fog, real-time texture color table updating, and indexing to meet the current generation simulation requirements at 60 Hz refresh rate. Document the practicality and feasibility of the approaches. Select an approach for development in Phase II. Assess any limitations in the design and technologies needing development. Characterize the approach's impact on overall system performance.

PHASE II: Develop the software and hardware identified in the Phase I approach. Assemble a prototype video card. Demonstrate the performance and functional capabilities including a real time simulation using a desktop PC. Finalize the video card hardware and software design for further development in Phase III.

PHASE III: Complete video card development. Conduct full-scale demonstration in a specified training system application. (The training system application will be identified during Phase II.)

COMMERCIAL POTENTIAL: Real-time, high-performance simulation of sensor-based imagery including night vision goggle scenes and thermal imagery. The ability to create high-quality, low-cost training simulation for police training. New generation of game scene rendering capabilities will be possible.

KEYWORDS: Simulation; Imaging; Sensors; Computer Hardware, PC Graphics, Real-time

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